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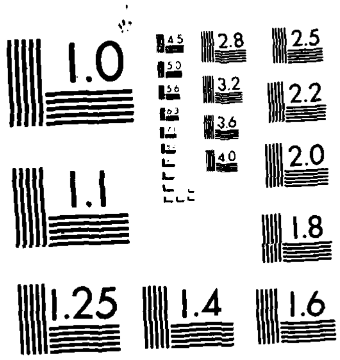

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AQUATIC PLANT CONTROL RESEARCH PROGRAM

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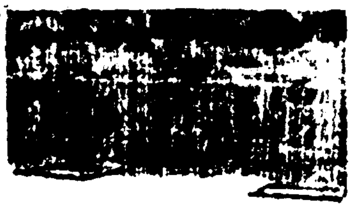
U.S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION

TECHNICAL REPORT A-83-2



INVENTORY AND ASSESSMENT OF AQUATIC PLANT MANAGEMENT METHODOLOGIES

By Elba A. Dardeau, Jr., Elizabeth A. Hogg

Environmental Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

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Final Report

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Native and exotic aquatic plants that adversely impact the major uses of the Nation's water resources are referred to as problem species. Operations personnel in Corps of Engineers (CE) Districts are responsible for managing the unchecked growth of these problem plants. Because the public has placed increased pressure on the CE to control problem species, these Districts need documentation of suitable management methods to develop and implement their own programs. This report documents and assesses available methodologies

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based on an inventory of current (since 1970) literature and a telephone survey of 14 CE Districts with active or recently active aquatic plant management programs. Although both surveys addressed all five elements of a successful aquatic plant management program (i.e., monitoring, reporting, treatment, public awareness, and training), considerably more information was found on treatment than on any of the other management elements. Both surveys yielded some information on monitoring methodologies but very little information on reporting, public awareness, or training. Although some of the aquatic plant management methodologies discussed in this report, especially in the area of monitoring (e.g., biomass sampling techniques), are only secondarily oriented to District operations programs, most have direct applicability to current District needs. These are, however, intermediate products of the research and development of "off-the-shelf" field methodologies.

This report also contains a listing of important problem aquatic plant species (Appendix A), and the questions and responses of the 14 CE Districts surveyed by telephone (Appendix B).

PREFACE

The study reported herein was conducted to help Corps of Engineers (CE) Districts develop aquatic plant management programs. Funds for this investigation were provided through the Aquatic Plant Control Research Program (APCRP) by the Civil Works Directorate, Office, Chief of Engineers (OCE), Washington, D. C., under Department of the Army Appropriation No. 96X3122 Construction General. Mr. J. Lewis Decell was Manager, APCRP, and Dr. John Harrison was Chief, EL.

This study was conducted from 1 October 1979 through 30 September 1980 by personnel of the Environmental Assessment Group (EAG), Environmental Resources Division (ERD), Environmental Laboratory (EL), U. S. Army Engineer Waterways Experiment Station (WES), under the direct supervision of Mr. Jack K. Stoll, Chief, EAG, and Dr. Conrad J. Kirby, Jr., Chief, ERD.

Mr. Elba A. Dardeau, Jr., EAG, planned the study and was responsible for the literature search. Ms. Elizabeth A. Hogg, EAG, conducted the telephone survey of the 14 CE Districts and assisted in the literature search. The aquatic plant management concepts contained in this report were originally developed in 1977 by Dr. Dana R. Sanders, Sr., Wetland and Terrestrial Habitat Group (WTHG), ERD, and by Mr. Decell as part of their presentation at the 1977 meeting of the Aquatic Plant Management Society in Minneapolis, Minn.

Special acknowledgement is made to Mr. K. Jack Killgore, Jr., Dr. Barry S. Payne, Mr. Anthony M. B. Rekas, all of the EAG, and to Dr. Sanders and Mr. Russell F. Theriot, WTHG, for their helpful guidance and suggestions during the course of this study. Dr. Sanders and Dr. Howard E. Westerdahl, Ecosystem Research and Simulation Division, EL, provided technical review. Mr. Dardeau and Ms. Hogg prepared this report.

Commanders and Directors of WES during the study and the preparation of this report were COL Nelson P. Conover, CE, and COL Tilford C. Creel, CE. Technical Director was Mr. F. R. Brown.

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CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
acres	4046.873	square metres
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*
feet	0.3048	metres
gallons (U. S. liquid) per acre	0.000000935	cubic metres per square metre
pounds (mass)	0.4535924	kilograms
pounds (mass) per acre	0.000112085	kilograms per square metre
square feet	0.09290304	square metres

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

INVENTORY AND ASSESSMENT OF AQUATIC PLANT MANAGEMENT METHODOLOGIES

PART I: INTRODUCTION

Background

1. Most native aquatic plants serve important ecologic functions. They add oxygen to the water during photosynthesis, provide a habitat for various kinds of aquatic life, stabilize the bottom sediment, synthesize food for aquatic life from sunlight and minerals, regulate nutrient availability, and inhibit the growth of free-floating algae (Koegel, Bruhn, and Livermore 1972). However, a number of the native species growing under ideal environmental conditions can interfere with the major uses of the Nation's water resources. In addition, most exotic plant species, when free from the environmental limitations that keep their growth in check in their native habitats, rapidly expand in the water bodies where they become established. These native and exotic plants that adversely impact on many user interests (including navigation, water supply, recreation, etc.) are referred to as problem species.*

2. The responsibility for dealing with the unchecked growth of problem aquatic species in the Nation's navigable waterways has been delegated to operations personnel in Corps of Engineers (CE) Districts. Because the public has placed increased pressures on the CE to determine the most suitable program for each management situation, these Districts need documentation of available methodologies to develop and implement their own programs.

3. In planning an aquatic plant management program,** operations personnel need to take into account not only the effectiveness of such a program but also economic, environmental, and social factors

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* Appendix A is a listing of important problem aquatic plant species (adapted from Decell (1977)).

** See Sanders and Decell (1977) for information on planning an aquatic plant management program.

(including compliance with all legal statutes). In some cases, a management program could satisfy environmental and social criteria but could also be economically infeasible. In other instances, an economically plausible program could have negative environmental or social impacts.

4. Aquatic plant management becomes necessary when population growth of one or more species poses an immediate or potential threat to human uses of a water body or to native biota. Depending on the magnitude of the population growth and the user-interest level, management can be implemented for one of these purposes: (a) prevention, (b) maintenance, and (c) control.

5. After a species becomes established in the water body, the pioneer colony grows until it impinges on some user interest and thus becomes a problem. Site-specific factors, such as user interests, size of the water body, and environmental considerations, determine the level of the population that first becomes a problem. Unless some treatment action is taken at this time, a further population increase will usually result in more severe impingement on user interests, thus further restricting or prohibiting the major public and private uses of the water body. If no treatment is implemented, the population will continue to grow until the species occupies the entire available habitat. As the population increases and causes a more severe problem, the applicability of available management methods becomes limited.

Rationale

6. Success of an aquatic plant management program, whether implemented for prevention, maintenance, or control, depends on effective implementation of five basic elements: (a) monitoring, (b) reporting, (c) treatment, (d) public awareness, and (e) training. Each element is discussed briefly below:

a. Monitoring (or surveying). The purpose of monitoring is to provide a means of detecting colonies of problem aquatic species, establishing population levels and distributions, and assessing the effectiveness of treatment measures. Monitoring generally involves the collection and analysis of

the appropriate combination of ground-survey and remote-sensing data;* however, in some small water bodies, monitoring can sometimes be accomplished without the benefit of remote-sensing surveys. Where the management objective is prevention, the monitoring element should emphasize the collection of ground-survey data, supplemented by those data derived from interpretation of remote-sensing products. On the other hand, if either control or maintenance of a problem aquatic plant species is the desired objective, more emphasis should be placed on the interpretation and analysis of remote-sensing products; however, these data are more meaningful when supplemented by ground-survey data. Monitoring should, at the very mimimum, address detection of colonies of a problem population, determination of areal extent of these colonies, and changes in areal extent of these colonies including those changes attributable to treatments (discussed under c), particularly in the areas of water bodies where user interest is highest (e.g., boat-launch facilities).

b. Reporting. Reporting, which provides systematic procedures for transmitting pertinent monitoring or treatment data on problem aquatic plants to management, can be satisfactorily accomplished through periodic documents that also include the results of applied treatments (discussed under c).

c. Treatment. Treatment programs are used to achieve the desired level of management of aquatic plant populations in any specified local environmental, social, or economic situation by effecting a reduction in biomass of a problem species compared with that of untreated populations. Treatment procedures can be grouped into five major categories: (1) chemical, which involves the placement of a known phytotoxic substance into the water; (2) mechanical, which involves any effort to physically alter or remove problem aquatic plants from a water body (including manual efforts); (3) biological, which involves the introduction of one or more organisms; (4) environmental management, which includes any human-induced modifications of the environment (e.g., water-level fluctuations); and (5) integrated treatments, which involve the use of any combination of the above four categories that results in a more effective treatment than could be achieved by use of any single method.

d. Public awareness. Public awareness involves the dissemination of information to the public to ensure awareness of aquatic plants, user impacts associated with a problem species, and available treatment programs. A public informed during the planning process (and not after all management decisions have been made) is more inclined to support a management program

* In this report, remote-sensing data are defined to include any data derived from an aerial perspective.

when it understands the nature of both the problem and subsequent choice of actions to be taken. This public support of management often results in the successful implementation of an aquatic plant management program.

e. Training. Personnel involved in operational aspects of aquatic plant management must be adequately trained in all management elements. The sequence of training varies with the level of the District's operational program.

Purpose and Scope

7. The purpose of this study was to inventory and assess available aquatic plant management methodologies and to provide this information in a single document to CE District operations personnel that are responsible for implementing management programs. The scope included documentation of management methodologies described in the literature and those being implemented in the 14 CE Districts contacted by telephone. Although some of the aquatic plant management methodologies discussed in this report, especially in the area of monitoring (e.g., biomass sampling techniques), are only secondarily oriented to District operations programs, most have direct applicability to current District needs. These are, however, intermediate products of the research and development of "off-the-shelf" field methodologies.

Approach

8. Literature and telephone surveys were conducted to determine which aquatic plant management methodologies were either available or being implemented by CE Districts. These surveys addressed all five elements of a successful program (paragraph 6).

Literature survey

9. Scientific journals, conference proceedings, technical reports, and other documents pertaining to aquatic plant management published since 1970* were reviewed. Most of the material located in the

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* A list of additional literature surveyed but not specifically cited herein is listed in the Bibliography following the References used to prepare this report.

course of the literature survey addressed the treatment element. A few references dealt with monitoring, while considerably less information was located on the reporting, public awareness, ar' training elements.

Telephone survey

10. Fourteen CE Districts with active (1980) or recently active aquatic plant programs were contacted by telephone and asked specific questions about each element of aquatic plant management (paragraph 6).* These Districts were selected on the basis of geographic and ecologic diversity, and they included both coastal and interior jurisdictions. Below is an alphabetical listing of the Districts selected for the telephone survey and the respective CE Divisions.

CE District	CE Division
Charleston (SAC)**	South Atlantic
Fort Worth (SWF)	Southwestern
Galveston (SWG)	Southwestern
Jacksonville (SAJ)	South Atlantic
Mobile (SAM)	South Atlantic
Nashville (ORN)	Ohio River
New Orleans (LMN)	Lower Mississippi Valley
New York (NAN)	North Atlantic
Norfolk (NAO)	North Atlantic
St. Paul (NCS)	North Central
Savannah (SAS)	South Atlantic
Seattle (NPS)	North Pacific
Tulsa (SWT)	Southwestern
Wilmington (SAW)	South Atlantic

The telephone survey questions addressed all five elements of an aquatic plant management program, as follows:

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* Time did not permit a survey of all CE Districts in the United States; however, an effort was made to include the Districts that have both problem plant populations and ongoing programs for dealing with these populations.

** SAC, etc., are abbreviations for the CE Districts.

Management Element	Question No.(s)
Monitoring	1 - 6
Reporting	7 - 8
Treatment	9 - 20
Public awareness	21
Training	22 - 23

Appendix B contains these 23 questions, followed by District responses.

PART II: MONITORING

11. Monitoring involves the collection of the appropriate combination of ground-survey and remote-sensing data, depending on the management objective (i.e., prevention, maintenance, or control).

Ground Surveys

12. Ground surveys are used to detect problem populations, to investigate reported populations, or to verify data obtained from remote-sensing sources. In a prevention program, these surveys serve as the principal means of quantitatively determining the status of problem aquatic plants in the District. For maintenance and control programs, ground-survey data supplement those data obtained from remote-sensing surveys because the distribution and size of the plant populations can be determined more economically by remote-sensing techniques. The level of detail of a ground survey also depends on temporal, fiscal, and manpower constraints and needs. For example, a District that has a large-scale management program (e.g., SAJ) can obtain only generalized ground-survey data, whereas a District that has a small-scale program can usually afford a greater level of detail.

13. Two types of ground surveys are the baseline and the posttreatment surveys, which can establish:

- a. Distribution and boundaries of the problem plant population.
- b. Species composition and biomass of the aquatic plant communities encompassing the problem population.
- c. Ranges of environmental parameters where the problem population is established and growing.

In some cases, temporal or fiscal constraints may not permit as complete a posttreatment survey as that originally made of the baseline conditions. Descriptions of methodologies for making each of these three determinations follow.

Distribution and boundaries

14. Districts can use fathometer surveys (Maceina and Shireman

1980; Shireman 1981) or professional divers (Dardeau and Lazor 1982) to aid in locating boundaries of submerged aquatic plant populations. Standard topographic surveys can then be used to map the distribution of a problem aquatic plant population with respect to fixed landmarks (e.g., benchmarks).* Buoys can serve as temporary markers during the ground survey or during any treatment. Distribution and boundaries of the plant population should be delineated on maps or a photomosaic of the water body and documented on data sheets and project field notebooks. If population boundaries are not delineated accurately, then posttreatment population changes cannot be monitored.

Species composition and biomass

15. District operations personnel should attempt to identify problem species and other plants in the communities encompassing the problem populations. When there is a question with identification of a problem species (e.g., in a water body where the problem species has not previously been detected), experts can be dispatched to the field, or field personnel can collect sample plants for identification and future reference.

16. If desired, biomass (i.e., weight of plant material per unit area) or biomass-density determinations (i.e., weight of plant material per unit volume) can also be made. Depth measurements are necessary to calculate biomass density. Over the past several years, a number of techniques and devices have been developed to sample biomass. These devices collect varying amounts of the total biomass of the aquatic vegetation present within a given column of water. Some of the equipment is cumbersome, requiring both divers and personnel in a boat. However, sophisticated biomass samplers, such as the U. S. Army Engineer Waterways Experiment Station (WES) biomass sampler (Figure 1), operate without the use of divers. The WES biomass sampler, mounted on a self-propelled craft, has a hydraulically operated sampling head that

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* Rekas and Bailey (1981) discuss existing instrumentation that can be adapted to monitor an aquatic plant population.

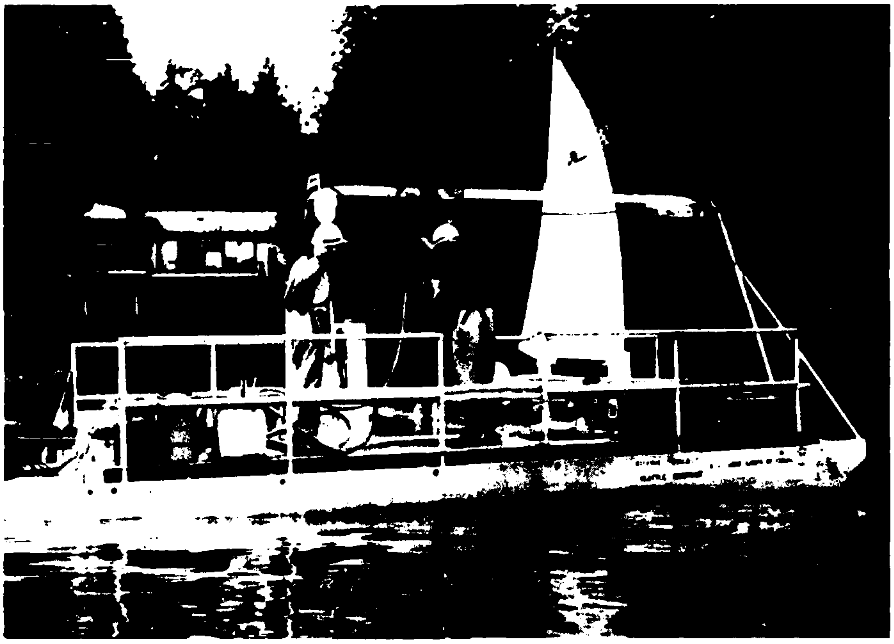

Figure 1. WES biomass sampler

collects vegetative material within a 2.87-ft^2* column of water. A set of three hydraulic system control levers are used to operate the:

a. Lift mechanism for the sampling head.

b. Cutting teeth on the outside of the sampling head.

c. Door closing rams on the inside of the sampling head.

The sampler requires a crew of at least three persons, one to control the craft and the other two to operate the sampling head and to remove, bag, and label the samples. Dardeau and Lazor (1982) describe the use of this sampling system.

Range of environmental parameters

17. In some management programs, a District may want to establish the ranges of environmental parameters that exist in the water body where problem aquatic plants occur. To establish such ranges, the

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 5.

sampling and measurement program should be designed to document the temporal and spatial (both horizontal and vertical) variations in the environmental parameters. Sediment samples can be collected for analyses of nutrients and particle-size distribution. Water samples can yield data on water quality (e.g., pH, dissolved oxygen, temperature, conductivity, etc.), nutrient levels, and herbicide residues. A number of devices, ranging from very simple equipment to complex instrumentation, have been developed for measuring various environmental parameters. The American Public Health Association (APHA) (1976) describes most of the standard methods for sampling and analyses. Rekas and Bailey (1981) discuss some of the more sophisticated instrumentation.

Remote-Sensing Surveys

18. Remote-sensing surveys, like ground surveys, can be used to establish either baseline or posttreatment conditions of problem aquatic populations. They serve as the primary means of data gathering for aquatic plant management programs where the objective is either maintenance or control, and as secondary sources in prevention programs. The data derived from remote-sensing surveys should be verified with ground-survey data. Remote sensing is an excellent monitoring tool for rapidly surveying large areas to locate, identify, and map plant populations.

19. Mission planning is an important aspect of any management program that involves the use of remote sensing. Struve and Kirk (1980) outline six steps of planning a remote-sensing mission as follows:

a. Mission definition.
b. Review of available imagery coverage.
c. Review of sources from which new imagery can be obtained.
d. Mission specification.
e. Quality control.
f. Processing data into final form.

These six steps take into consideration:

- a. Format and scale requirements of final product.
- b. Type of interpretation required.
- c. Selection of appropriate altitude, time of day, and time of year.
- d. Determination of solar altitude and maximum acceptable cloud cover and shape.
- e. Selection of camera and optimum film-filter combination.

20. Long (1979) discusses remote sensing of aquatic plants and the merits of various remote-sensing systems, including Landsat, side-looking airborne radar, and conventional aerial photography. Table 1, adapted from Rekas (1980), presents preliminary findings on various remote-sensing systems, considering their suitability for aquatic plant management applications. There is a great deal of variation among the different remote-sensing systems; therefore, management should examine the merits of the available systems when planning a remote-sensing mission. If necessary, more than one system or scale can be used to survey a particular water body.

21. Mission planning also involves consideration of temporal and fiscal constraints, which, in some cases, will force management to substitute a less satisfactory remote-sensing product. Two examples below illustrate how each of these constraints can be determining factors in mission planning.

- a. Example 1 - temporal constraint - Management determines that color infrared coverage of a water body will yield the best contrast for mapping a population of an emergent aquatic species. Time required for processing the exposed film is too great to allow for interpretation. Another film (black and white) that can be processed rapidly at a local laboratory is substituted.
- b. Example 2 - fiscal constraint - Management favors 1:5,000-scale color film to make a baseline survey of a submerged aquatic plant population in a large reservoir. Sufficient funding is available either for partial coverage with that particular film-scale combination or for complete coverage with 1:10,000-scale black-and-white photography. Management elects to fly the smaller scale black-and-white photomission to get complete coverage of the water body for this baseline survey.

22. The system and end product chosen for the baseline survey should also be used for any posttreatment survey. A detailed discussion of the use of remote sensing for determining aquatic plant distribution is in preparation (Leonard 1983), while another report, also in preparation (Dardeau 1983), presents four case studies that illustrate the application of aerial surveys to mapping and monitoring aquatic plant populations.

Responses of the CE Districts

23. Questions 1 through 6 of Appendix B deal with monitoring practices of the 14 CE Districts. The responses indicated that ground and remote-sensing surveys are used. All Districts attempted to identify problem aquatic plants to the species level; however, these problem species and their areal extents are quite varied. The level of monitoring ranged from no monitoring at all to that of monitoring any size problem population, no matter how small.

PART III: REPORTING

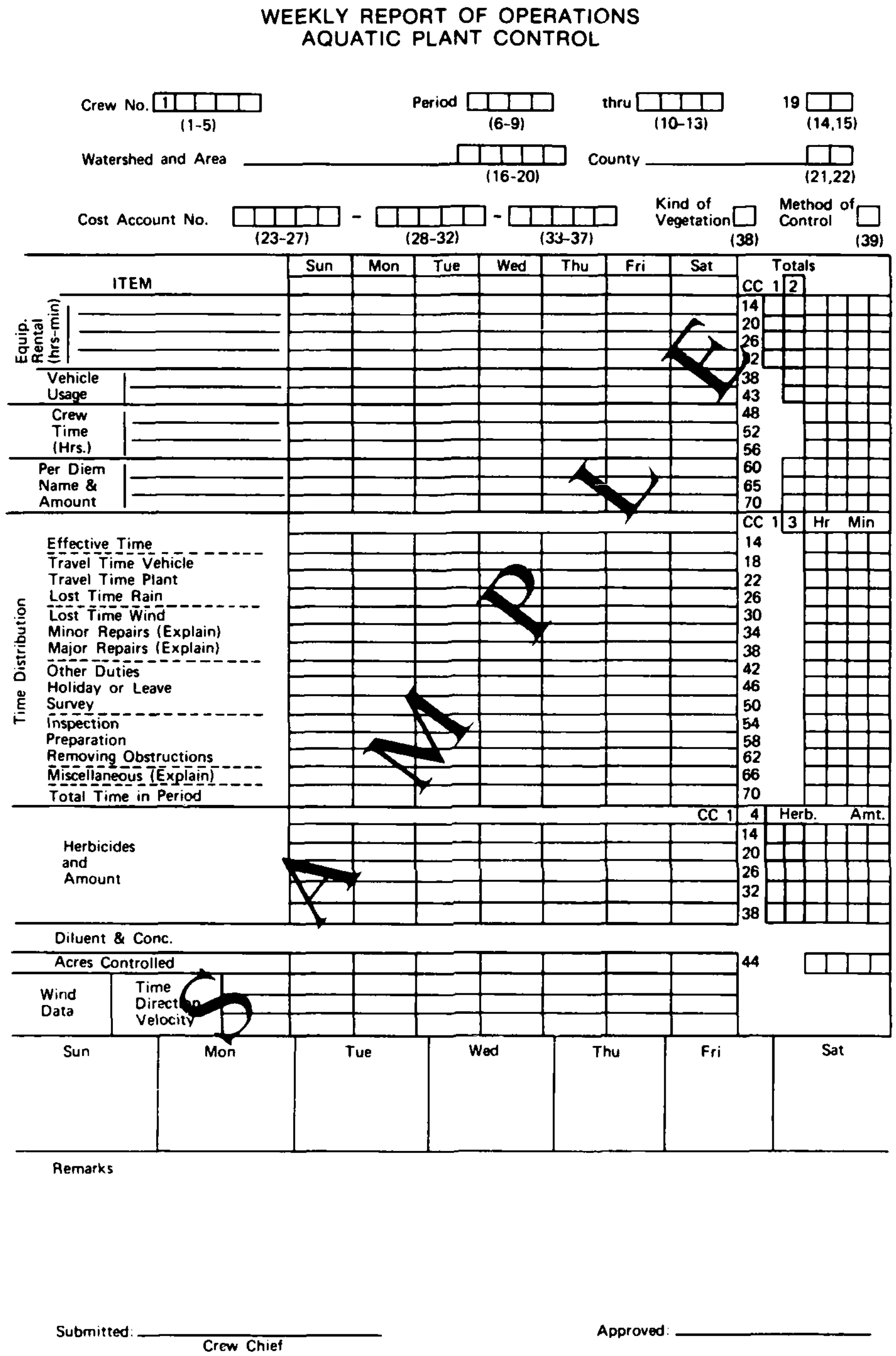
24. Reporting provides a systematic procedure for transmitting aquatic plant monitoring and treatment information to management. Unfortunately, there is very little published information documenting procedures for reporting and almost no interaction among agencies involved in aquatic plant management programs. Thus, the currently used reporting procedures have evolved independently. Reporting of both the monitoring and treatment elements of aquatic plant management is discussed below.

Monitoring Element

25. The CE Districts that have ongoing monitoring programs use their own staffs (or that of a State agency with whom they have an agreement to manage their aquatic plant program) to report on the status of aquatic plant populations in the water bodies under their jurisdiction. Many Districts, however, rely on the public to bring to their attention the existence or change in status of a plant population. The manner in which the public notifies the District of these populations ranges from verbal or telephone reports to written documentation. Because an uninformed public often confuses useful native aquatic flora with problem species, trained personnel should be dispatched to verifiy a reported plant occurrence. Question 7 of Appendix B deals with procedures for reporting the occurrence of problem plant populations. The responses showed that none of the 14 CE Districts contacted had any special forms or procedures for either the public, CE District, or State agency employees to report the presence or the status of these populations.

Treatment Element

26. With the possible exceptions of McGehee (1977) and U. S. Army Engineer District, Jacksonville (1978), which addressed reporting of treatment operations in SAJ, there is little documentation on reporting procedures used by the 14 CE Districts surveyed. Figure 2 shows SAJ



WEEKLY REPORT OF OPERATIONS
AQUATIC PLANT CONTROL

Crew No. 1 (1-5) Period (6-9) thru (10-13) 19 (14,15)

Watershed and Area (16-20) County (21,22)

Cost Account No. (23-27) - (28-32) - (33-37) Kind of Vegetation (38) Method of Control (39)

ITEM		Sun	Mon	Tue	Wed	Thu	Fri	Sat	Totals
									CC 1 2
Equip. Rental (hrs-min)									14
									20
									26
									32
Vehicle Usage									38
									43
Crew Time (Hrs.)									48
									52
									56
Per Diem Name & Amount									60
									65
									70
									CC 1 3 Hr Min
Time Distribution	Effective Time								14
	Travel Time Vehicle								18
	Travel Time Plant								22
	Lost Time Rain								26
	Lost Time Wind								30
	Minor Repairs (Explain)								34
	Major Repairs (Explain)								38
	Other Duties								42
	Holiday or Leave								46
	Survey								50
	Inspection								54
	Preparation								58
	Removing Obstructions								62
	Miscellaneous (Explain)								66
	Total Time in Period								70
								CC 1	4 Herb. Amt.
Herbicides and Amount									14
									20
									26
									32
									38
Diluent & Conc.									
Acres Controlled									44
Wind Data	Time								
	Direction								
	Velocity								

Sun	Mon	Tue	Wed	Thu	Fri	Sat

Remarks

Submitted: ______ Crew Chief

Approved: ______

SAJ Form 454
26 Jun 78

SAMPLE

Figure 2. SAJ Form 454, "Weekly Report of Operations, Aquatic Plant Control" (redrawn for use herein)

Form 454, entitled, "Weekly Report of Operations, Aquatic Plant Control," and Figure 3 shows a typical SAJ computer printout. Question 8 of Appendix B deals with reporting treatment measures planning future aquatic plant management operations. The responses were quite varied. Five Districts (SWG, SAJ, LMN, SAS, and SWT) reported having forms for documenting treatments; however, only SAJ and SAS reported that their forms were computer-compatible. In those Districts having contracts with State agencies to perform treatments of aquatic plant populations (e.g., SWF, SWG, etc.), the reports also serve as accounting documents to compensate the State agencies for their work. These reports range from simple field logs to more sophisticated computer printouts.

31 MAR 80

U S ARMY ENGINEER DISTRICT, JACKSONVILLE
MONTHLY SUMMARY AQUATIC PLANT CONTROL

PROGRAM KM27002

SUMMARY BY STATE CONTRACTORS

ITEM	SFWMD	SWFWMD	CITRUS	HIGLANDS	HILLSBGR	LAKE	LEE	ORANGE	POLK	G&FWFC
1-AIRBOAT	368,00	454,00	240,00	168,00	86,00	20,00	28,00	33,00	224,00	709,00
2-AIRCRAFT										112,00
3-KICKERBOAT	32,00				7,30	55,00	7,00	22,00	48,00	
11-TANK TRUCK AIRCRAFT										112,00
13-BATCH TRUCK 1 TON		213,30			60,00					
22-BARGE								47,00		
23-PONTOON BOAT								27,00		
25-HELICOPTER									8,00	
1-SEDAN										129,00
3-P,U, TRUCK 1/2 TON	32,00	251,00							88,00	
4-P,U, TRUCK 3/4 TON	400,00				135,00					736,00
5-P,U, TRUCK 1 TON			240,00			98,00	35,00			
6-BLAZER CARRYALL WAGON		10,30		168,00				129,00	184,00	108,00
CREW TIME A	432,00	431,00	230,00	168,00	190,30	82,00	35,00	161,00	280,00	881,00
CREW TIME B	296,00	391,00	200,00	168,00	176,30	48,00	35,00	157,00	280,00	941,00
CREW TIME C	88,00	90,00	30,00	136,00	70,00	3,00		125,00		157,00
TOTAL MAN HOURS	816,00	912,00	460,00	472,00	436,60	133,00	70,00	443,00	560,00	1979,00
PER DIEM A	,00	,00	,00	,00	,00	,00	,00	,00	,00	651,50
PER DIEM B	,00	,00	,00	,00	,00	,00	,00	,00	,00	662,00
PER DIEM C	,00	,00	,00	,00	,00	,00	,00	,00	,00	35,00
TOTAL PER DIEM	,00	,00	,00	,00	,00	,00	,00	,00	,00	1348,50
EFFECTIVE TIME	178,00	142,00	106,30	6,00	33,00	37,00	9,30	59,00	91,00	42,30
TRAVEL TIME VEHICLE	98,00	92,30	34,00	11,00	42,00	27,00	6,30	28,30	40,30	253,30
TRAVEL TIME PLANT	38,30	26,00	35,30	11,00	10,00			7,00	22,00	5,30
LOST TIME RAIN	6,00	21,30	5,00	8,00	2,00			10,00	1,30	37,00
LOST TIME WIND	9,30	32,00	2,00	16,00			3,00	30,00	70,30	378,00
MINOR REPAIRS	8,30		9,00		26,00	5,00			7,00	64,30
MAJOR REPAIRS	6,00		12,00		5,00		3,30		19,30	40,00
OTHER DUTIES		2,30			44,30					36,30
HOLIDAY AND LEAVE					80,00					
SURVEY			2,00	116,00	5,00	12,00				4,00
INSPECTION	52,00	6,30			10,00	6,00	8,00		5,00	36,00
PREPARATION	34,30	16,30	31,00		4,30	15,00	4,30	16,30	30,30	28,00
REM OBSTRUCTIONS	1,00	85,00			78,00	4,00		12,00	,30	80,30
MISCELLANEOUS		14,30	2,00					6,00		30,00
TOTAL TIME	432,00	441,00	239,00	168,00	340,00	106,00	35,00	169,00	288,00	1036,00
1-2,4-D AMINE	3					62		2	111	115

Figure 3. Typical printout derived from data recorded on SAJ Form 454

PART IV: TREATMENT

27. Treatment programs should be designed to achieve the desired level of management for problem aquatic plant populations. Potential users need to examine not only effectiveness but also the environmental, social, and economic ramifications of any proposed treatment. Treatment methods are grouped into five major categories: chemical, mechanical, biological, environmental management, and integrated treatments. Each is discussed below.

Chemical

28. Fewer than 10 chemical compounds are registered nationally by the U. S. Environmental Protection Agency (EPA) for treatment of aquatic plant populations. In addition, other herbicides have labels restricting their use to specific local situations. For example, Section 18 of the Federal Environmental Pesticide Control Act of 1972 (FEPCA) permits the EPA Administrator to exempt any Federal or State agency from the provisions of the Act if he determines that emergency conditions exist, and Section 24(c) of the FEPCA permits states to register herbicides for intrastate distribution and use to meet specific local needs.* Chemical compounds have been developed to treat plants in all of the various categories of problem aquatic plant species shown in Appendix A (e.g., algae, emergent plants, etc.). Potential users should always study herbicide labels prior to any intended use. In the following paragraphs, environmental and social factors affecting herbicide effectiveness, delivery and application of herbicides, and responses of the CE Districts are discussed.

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* The EPA regulations governing the use of aquatic herbicides are very frequently changed. Potential aquatic herbicide applicators should contact the nearest Regional EPA office and appropriate State agency to determine which herbicides are currently available.

Environmental and social factors
affecting herbicide effectiveness

29. Management should be aware of the environmental and social factors affecting the effectiveness of a herbicide proposed for treating a population of a problem species. Environmental factors include:

a. Water movement. Movement of water affects herbicide dispersion, thus reducing contact time to plant.

b. Water depth. The greater the depth of the water body, the greater the volume of water that must be treated. To effect the same level of treatment of a problem species in a larger volume of water, a greater volume of herbicide is generally required. Some herbicide labels specify treatment rate by volume (e.g., endothall) while others by water body surface area (e.g., 2,4-D).

c. Water quality parameters. A number of important water quality parameters include hardness, alkalinity, water temperature, and suspended solids. These parameters either affect herbicidal activity or reduce the contact between the herbicide and the cuticle of the plant.

d. Detritus. Detritus affects availability of the herbicide by effecting breakdown of the formulation in the aquatic environment.

e. Growth form, biomass, and relative abundance of problem species. The growth form (i.e., emergent, floating, or submerged) determines method of delivery (paragraph 31). Any increase in biomass is directly porportional to the increased quantity of active ingredient required to effect the same level of treatment. Relative abundance of a problem species can affect the choice of a more (or less) selective herbicide.

f. Timing (both seasonal and diurnal) and its relation to plant life cycle. Nutrient (and herbicide) uptake fluctuates both seasonally and diurnally, and potential users should determine the best season and time of day for application to achieve the best treatment results.

g. Climatic factors. Climatic factors need to be considered. Wind can cause dispersal, and precipitation can remove a herbicide from above-water (i.e., floating or emergent) problem species. Air temperature can affect herbicide viscosity.

Many of these factors can either be measured or obtained from existing published or unpublished sources. For example, many CE Districts or other Federal or State agencies maintain and publish records of

stream-gaging or water quality stations in water bodies where problem plants occur. These agencies often survey cross sections or conduct hydrographic surveys in the water bodies of interest. There may also be existing plant physiology and nutrient uptake studies dealing with the problem species.

30. Among the more important social factors that should be considered is the proximity of the problem plant population to residential, agricultural, and recreational areas and wildlife habitats. When a problem plant population is adjacent to one of these critical areas, management must take special precautions to select a herbicide and a method of application (paragraph 31) that will effectively treat the problem plant population, while at the same time minimizing any deleterious impacts on the surrounding areas. Management should determine the locations of water intakes (e.g., for irrigation, household use, livestock, etc.) and outfalls (e.g., storm drains, industrial effluents, etc.) before implementing a chemical treatment program. Water users should be contacted to determine the use of the water being removed from the water body, to explain the purpose of the proposed herbicide treatment, and to secure permission for treatment in the vicinity of the intake. Effluents should also be identified to determine what effect they could have on water quality (e.g., pH, temperature, etc.) and herbicide drift. A District should know of its responsibility for informing the public (see Part V: Public Awareness), for safe handling and application of herbicides, and for marking of treated areas with appropriate information concerning restricted use of the area.

Delivery and application of herbicides

31. Herbicides are available in either liquid or granular formulations and can be delivered in any of the following manners:

a. Unmodified. Formulation applied as manufactured to a problem plant population in a water body.

b. Invert emulsions. Water in an oil emulsion that inverts when placed in a water body.

c. Polymers. Herbicide and polymer combine to form a matrix that adheres to the plants.

d. Controlled-release (CR) formulations. Slow release of active ingredient over a long period of time at a low concentration.

Application methods commonly used include spraying, using trailing hoses, or broadcasting from boats, fixed-wing aircraft, or helicopters. Hand spraying could also be feasible on a small scale in certain situations. The herbicide formulation and the methods of delivery and application will depend on the problem species and the site conditions of the water body to be treated. For example, a submerged problem species can be treated effectively with either sinking granules or herbicides delivered by trailing hoses. Other methods of delivery and application should be considered for floating or emergent populations. The CR formulations will provide a means of regulating delivery of a low concentration of the active ingredient to the plant. At present, no CR formulations are registered; however, manufacturers will likely seek registration for efficacious formulations.

32. Environmental factors (paragraph 29) are also very important in herbicide delivery and applications. For example, management would approach treating a problem population in a moving stream differently from treating another population of the same species in a reservoir or small pond because of the effects of current on herbicide drift. Social factors (paragraph 30) also determine the method of application. For example, aerial spraying of a water body adjacent to residential, agricultural, recreational, or wildlife areas could cause damage to beneficial plants, wildlife, and even to human life, whereas hand spraying could effect the desired treatment without harmful side effects.

Responses of the CE Districts

33. Question 13 of Appendix B deals with chemical treatments. Table 2 summarizes these responses and includes herbicide names, problem species on which these herbicides have been used, and the CE District making these treatments. This table shows that these Districts use various forms of 2,4-D on alligatorweed (*Alternanthera philoxeroides* (Mart.) Griseb.), Eurasian watermilfoil, waterchestnut (*Trapa natans* L.),

floating waterhyacinth (*Eichhornia crassipes* (Mart.) Solms.),* and fragrant waterlily (*Nymphaea odorata* Ait.). Other important herbicides used for treatment of problem plant populations include diquat (for Brazilian elodea (*Egeria densa* Planch.), common duckweed (*Lemna minor* L.), and fragrant waterlily and endothall (for Brazilian elodea, Eurasian watermilfoil, and hydrilla).

Mechanical

34. Mechanical treatment is any effort to physically alter or remove problem aquatic plants from a water body. This includes hand removal, fragment barrier systems, mechanical harvesting, rototilling, and dredging. Hand removal is probably the oldest method of treating problem aquatic plant populations, and it is still used in small-scale operations. Fragment barrier systems and mechanical harvesters are also used in aquatic plant management programs. Rototilling and dredging are of much less importance. Each of the three most important means of mechanical treatment, hand removal, fragment barrier systems, and mechanical harvesters, is discussed below.

Hand removal

35. Hand removal of problem aquatic species is feasible only in a small-scale prevention program. This technique has been used mainly in the vicinity of boat-launch facilities where a pilot colony has become established. Limitations on hand removal include size of colony, available time and manpower, water depth (ideally, waist deep or less), water temperature, underwater visibility, type of bottom sediment, biomass of problem species, and biomass of competing species. There has been little documentation on the hand-removal technique, with the possible exceptions of that performed by a WES field team on Lake Osoyoos and on the Okanogan** River in north-central Washington in the summer of 1979 (Dardeau and Lazor 1982) and that in the state of New York (Hook 1977).

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* Hereafter referred to as waterhyacinth.
** The name of this river is spelled "Okanagan" in Canada.

In the former exercise, the team attempted to remove as many Eurasian watermilfoil plants and their roots as possible from three plots; although generally there was good success at removal of Eurasian watermilfoil, the manual method proved to be very tedious and time-consuming. In New York, the hand-removal efforts were directed toward small colonies of waterchestnut. Average cost (1974) of waterchestnut removal was $69.27/acre, and estimates of harvest time ranged from 1/20 acre to 1 acre/man-day, depending on biomass.

Fragment barrier systems

36. A fragment barrier system is any means used to physically isolate a colony of a problem aquatic plant species and thus prevent the dispersal of viable plants or fragments in a water body by current, wave, or wind action. Fragment barriers can be either simple or complex devices, their construction depending on the growth form of the problem species (i.e., floating, emergent, etc.) and the temporal, fiscal, and manpower constraints. The early barriers were crude log booms. Later, more sophisticated barrier systems evolved, and there are now several firms selling such products. In addition, fragment barrier systems can be custom-built to meet site-specific requirements.

37. The British Columbia Ministry of the Environment (1978) and Dardeau and Lazor (1982) reported on fragment barrier systems built and operated on streams of the Okanogan River Basin in British Columbia and in north-central Washington. In the former study, the British Columbia Ministry of the Environment deployed a number of barriers and evaluated their effectiveness by means of sampling cages placed upstream from the barriers. These cages provided "a measure of the vertical stratification of all waterborne material passing through a specific water column during a known period of time" (British Columbia Ministry of the Environment 1978); however, this study made no provision for measuring the dispersal of viable fragments downstream from the barrier.

38. In the latter effort (Dardeau and Lazor 1982), the NPS constructed a fragment barrier system on the Okanogan River at Oroville, Wash., and operated it for a 12-week period during the summer and fall of 1979. This system consisted of (a) a debris barrier, designed to

intercept large floating material (e.g., logs); (b) an operational barrier placed downstream from the debris barrier, designed to collect Eurasian watermilfoil fragments; and (c) two evaluation barriers, one upstream and the other downstream from the operational barrier. The WES and NPS used the evaluation barriers to measure the efficiency of the operational barrier. These evaluation barriers were constructed as five sets of six vertically arranged 1-ft^2 screens that sampled the river cross section; the upstream barrier served as the control for the experiment, and the downstream barrier measured the material that had escaped the operational barrier. Dardeau and Lazor (1982) reported that the NPS operational barrier had an average weekly effectiveness of 66.2 percent.

Mechanical harvesters

39. Mechanical harvesters either cut (rooted plants) or dislodge (floating plants) and then remove aquatic vegetation from a water body, place it in a holding area, and transfer it to a transporter. The transporter moves each load of harvested vegetation to a shore conveyor and then to dump trucks for disposal, the final step in the harvesting process.

40. Advantages and limitations. There are a number of mechanical harvesters on the market, and many of these devices have been used by CE Districts in their aquatic plant management programs. Culpepper and Decell (1978) listed both advantages and limitations of mechanical harvesting. Advantages are:

- a. Provides immediate relief in the treatment area.
- b. Adds no foreign substance to the aquatic environment.
- c. Removes a high biological oxygen demand from the aquatic ecosystem.
- d. Yields harvested vegetation that can provide a potentially useful resource.
- e. Controls the amount of plant material removed from the water body.

The limitations include:

- a. Low efficiency (at best, a temporary solution).
- b. Relatively high cost (when compared with other treatment methods).

c. Lack of adequate nearby land-based disposal sites, thus accelerating disposal costs.

41. Koegel (1979) pointed out that the surface area of problem populations harvested per unit time is inversely proportional to unit biomass. The amount of biomass that can be harvested per unit time increases in direct proportion with increased unit biomass; however, management is usually more concerned with area harvested, rather than with biomass harvested, per unit time. Other factors that enter into mechanical capability include wind, current, and wave action, and harvester and operator efficiency. Generally, the average harvest rate with available harvesters is 0.4 to 0.5 acre/hr. Harvesting submerged plants incurs a certain element of risk caused by the presence of underwater obstacles, which can cause downtime (Koegel 1979).

42. Handling of harvested vegetation. The rate of harvest and the rate of handling of aquatic vegetation are limiting factors in mechanical control. Rollers can be used to press the vegetation and remove excess moisture; however, this liquid contains nutrients that can alter the chemistry of the water body, thus setting the stage for future adverse effects (e.g., algal blooms, etc.) (Koegel, Bruhn, and Livermore 1972). Management sometimes finds chopping the harvested plants advantageous to allow for ease in handling and transporting. The amount of time spent on transportation depends on the size and configuration of the water body (Koegel 1979).

Responses of the CE Districts

43. Question 14 of Appendix B deals with mechanical treatment of aquatic plants. Table 3 summarizes the District responses. Ten Districts reported using no form of mechanical treatment. Of the four Districts using mechanical treatment, two Districts (SAJ and SAM) reported using mechanical harvesters; one District (NAN) used hand removal on waterchestnut populations on a regular basis (see paragraph 35); another District (NPS) had constructed a barrier system designed to prevent or impede the downstream dispersal of Eurasian watermilfoil fragments on the Okanogan River in north-central Washington (see paragraph 38).

Biological

44. Most problem aquatic plants are exotic species that were introduced to this country without the natural agents that keep their growth in check. A logical approach is, therefore, to search the native habitats of these exotic species to determine which (if any) of the natural agents can be used for biological treatment in the United States. Host-specificity tests must then be conducted under quarantine conditions before any agent is introduced for wide-scale use. The three most common means of biological treatment are insects, pathogens, and fishes. There are other potential biological agents that have been used, mainly on a limited or localized basis. Each category is covered briefly. In addition, the responses of the CE Districts are summarized.

Insects

45. At least three problem species of aquatic plants have been treated successfully with insect agents and reported in the literature. These are alligatorweed, waterhyacinth, and waterchestnut. Very little information has been published on the methods of treatment using insect agents. One report (U. S. Army Engineer Waterways Experiment Station 1981), however, deals with the use of insects on alligatorweed populations.

46. Alligatorweed. The U. S. Department of Agriculture (USDA), under the sponsorship of the CE Aquatic Plant Control Research Program (APCRP), was responsible for conducting the first biological treatment program. This agency introduced three insects as agents against the alligatorweed, including the alligatorweed flea beetle (*Agasicles hygrophila* Selman and Vogt) in 1964, a stem-boring moth (*Vogtia malloi* Pastrana) in 1971, and a thrips (*Amynothrips andersonii* O'Neill) in 1976 (Center 1979).

47. *Agasicles* has been used to successfully treat alligatorweed in the United States. This beetle is capable of overwintering as far north as Columbia, S. C., and probably even in southern North Carolina (Coulson 1974). Coulson (1974) reported that *Agasicles* appeared to have reduced the aggressiveness of alligatorweed and the extent of the

alligatorweed population and that this insect seemed capable of further reducing alligatorweed, within limitations, to a lesser economic role in the environment. Gholson (1977) stated that this beetle has succeeded in checking the growth of alligatorweed in Lake Seminole, Alabama-Florida-Georgia. Martin (1978) reported that *Agasicles* was released in five areas from 1967 through 1975 in SWG, and the insect has proved to be a "limited success" in terms of its impact on alligatorweed.

48. Thompson (1978) reported that a significant population of *Vogtia* had survived the winter of 1976-1977 in Louisiana; however, the moth inflicted only slight damage to the alligatorweed population. *Vogtia* also appeared to cause slight damage in SAM, especially along the coast (Eubanks 1978). Gates (1978) also reported that *Vogtia* was well established along the Arkansas River.

49. Gangstad et al. (1975b) reported that 1200 thrips were released on alligatorweed populations in Georgia and South Carolina in 1967. These insects attacked leaves on the first few internodes. Damage inflicted by the thrips was less pronounced than that inflicted by *Agasicles*. However, massive populations of thrips could potentially serve as a growth regulator for alligatorweed.

50. Waterhyacinth. Under the sponsorship of the APCRP, the USDA directed its biological treatment efforts against the waterhyacinth in Florida. For this effort, this agency used three insects, the mottled waterhyacinth weevil (*Neochetina eichhorniae* Warner) in 1972, the chevroned waterhyacinth weevil (*N. bruchi* Hustache) in 1974, and the Argentine waterhyacinth moth (*Sameodes albiguttalis* Warren) (Center 1979).

51. Center (1979) stated that *Neochetina* feeds on the waterhyacinth leaves and produces small feeding scars. This insect lays its eggs in the leaf tissue, and the larvae burrow down through the leaf petioles and ultimately into the rhizome of the plant. Deloach and Cordo (1976) reported that *N. bruchi* prefer to oviposit in the older bulbous petioles and that *N. eichhorniae* prefer the slender petioles of the young equitant leaves of the central bud. These two weevils alternate in abundance and therefore complement each other in a treatment program (Deloach and Cordo 1976). Perkins and Maddox (1976) conducted

host-specificity studies and determined that damage was negligible outside the family Pontederiaceae. *Neochetina bruchi* has also been used in combination with the white amur or grass carp (*Ctenopharyngodon idella* Val.) for treatment of waterhyacinth in Florida (Del Fosse, Sutton, and Perkins 1976).

52. Since *Sameodes* has been established in Florida, it has reduced the vigor of waterhyacinth populations; however, the impact of this biological agent has not been fully evaluated (Center 1979). This moth has also been released in Louisiana and is dispersing (R. F. Theriot 1981).

53. Waterchestnut. Hook (1977) stated that only one insect, the chrysomelid beetle (*Galerucella nymphaeae* L.), was found to feed on waterchestnut foliage. This beetle inflicted only minor damage to its host.

Pathogens

54. Plant pathogens, a diverse group of organisms that includes fungi, bacteria, viruses, and nematodes, appear to be ideal agents to treat populations of problem species. Both native and exotic species have been tested on alligatorweed, hydrilla, Eurasian watermilfoil, and waterhyacinth. The fungus, Cercospora rodmanii Conway, has been successfully used by LMN to treat waterhyacinth populations in Louisiana (E. A. Theriot 1981). This pathogen was prepared as a dry powdered formulation that was mixed with water and a surfactant and applied with sprayers. In addition, the fungal pathogen, *Fusarium roseum* 'Culmorum' (Lk. ex Fr.) Synd and Hans, has been effective on hydrilla in laboratory tests (Charudattan 1981).

Fishes

55. Herbivorous fishes have also been used as biological agents. The white amur has been the most effective in terms of its impact on problem aquatic plants. Other species of lesser importance and, therefore, less documented in the literature are the Israeli carp (*Cyprinus carpio* L.) and the tilapia (*Tilapia* spp.).

56. White amur. The white amur, a native of China, was introduced to this country as a means of biological treatment of problem

aquatic plants. The first major release of this fish was by the Arkansas Game and Fish Commission (AGFC) in 1969 in Lake Greenlee. This water body was cleared of coontail (*Ceratophyllum demersum* L.) by the summer of 1970, and the white amur had a positive effect on native fish production. Later, the AGFC released the white amur in other Arkansas lakes (Gangstad, Raynes, and Burress 1973).

57. Decell (1977) and Thomas (1977) pointed out that the CE has sponsored research at the U. S. Department of the Interior Fish Farming Experiment Station at Stuttgart, Ark. In 1972, this research resulted in the production of monosex (all female) white amur offspring (Stanley 1976). Twenty-five of these monosex fish were released in Lake Conway, Florida, in 1974 (followed by later releases) to treat hydrilla populations (Theriot 1977 and Ware 1978). Lazor (1979) stated that determining the biomass of white amur that must be introduced to a water body is necessary to achieve the most effective treatment of the problem aquatic species. Only 11 states permit the introduction of the white amur. Other states, such as Louisiana, permitted limited research from 1972 until 1974 with a hybrid carp (using the Israeli carp female and the white amur male). Originally, these fish were thought to be sterile, but later tests proved them capable of reproduction (Hughes 1978).

58. Israeli carp and tilapia. The Israeli carp is not useful for treatment of rooted aquatic plants; however, this fish has been somewhat successful in controlling filamentous algae. The tilapia, a native of the Middle East and Africa, has also been used in an attempt to control submerged aquatic plants in California and Florida but must be restocked annually in waters cooler than 72°F (Ad Hoc Panel 1976).

Other potential biological agents

59. In addition to insects, pathogens, and fishes, there are a number of other herbivorous species that are potential biological agents for treatment of problem aquatic plant species. These include manatees, crayfish, waterfowl, snails, and even water buffalo. Use of these organisms, however, has not proved to be practical, even in their native

countries. More research is needed to determine the feasibility of other biological agents for treatment of problem aquatic plant populations. Ad Hoc Panel (1976) contains details of the potential use of these herbivorous organisms as biological agents.

Responses of the CE Districts

60. Question 15 of Appendix B deals with the use of biological agents on aquatic plant populations, and Table 4 summarizes the Districts' responses. Nine of the fourteen Districts reported using insects as a means of treatment, while the other five Districts reported no biological treatment. The LMN used the fungus, *Cercospora rodmanii*, while the SAJ stated that it was conducting research on pathogens. The SAJ and SAS reported experimental use of the white amur. A number of the Districts using biological treatment reported good results with insects, while others (e.g., NAN) reported only limited success. In other Districts, the extent of success of biological treatment has not been established because these agents had not been used long enough to obtain any accurate measure of effectiveness.

Environmental Management

61. Environmental management includes any induced modifications of the environment intended to effect reduction of the population of one or more problem aquatic macrophytes. Perhaps the most common management technique that can be classified as environmental management is water-level fluctuation. Another is a permeable bottom screen that prevents sunlight from reaching the plants. A third method involves the use of inert chemicals that color the water to shade the plants from the sunlight.

Water-level fluctuation

62. Many aquatic species cannot tolerate extreme fluctuations in water levels; thus, water-level adjustment can be an effective management technique. Fluctuation of water levels is possible as a treatment in a water body where flows can be controlled, such as a reservoir; however, the multipurpose allocations (e.g., power generation, water supply,

irrigation, recreation, navigation, etc.) of some of the larger reservoirs may not permit the variation of water level that is necessary to effect the desired level of treatment.

63. There have been a number of studies (e.g., Goldsby and Sanders 1977; Hestand et al. 1973; Manning and Sanders 1975; Richardson 1974; and Richardson 1975) dealing with the impact of water-level fluctuation on aquatic plant populations. In general, these researchers found that drawdowns (especially consecutive drawdowns) are effective for reducing the growth of submerged vegetation. At the same time, drawdowns may permit the establishment of problem aquatic plants in areas that become shallow enough to support their growth; however, these authors stated that appropriately timed drawdowns (normally in the fall) and reflooding (usually in mid-to-late winter) have afforded the maximum treatment benefit.

Bottom screens

64. The concept of using bottom coverings to inhibit growth of aquatic plants is not a new one. For example, Nichols (1974) and Mayer (1978) reported that sand, gravel, and polyethylene sheeting were used in Wildfall Lake, Wisconsin, although with only limited effectiveness. Bottom screens are made of permeable synthetic materials (e.g., polyvinyl-coated fiberglass) that absorb about half of the incident radiation (depending on mesh size) and restrict the portion of the water column available to the plant. These devices minimize both the logistic problems involved with hauling sand and gravel and the deleterious impact on the benthic community caused by using nonporous sheeting (Mayer 1978). Bottom screens interfere with normal photosynthetic activity, which results in a net reduction in biomass of the rooted aquatic plants covered by the screens (Perkins, Boston, and Curren 1979).

65. Mayer (1978), reporting tests results with the product, Aquascreen (manufactured by Menardi-Southern Corporation of Houston, Tex.), conducted from 1973 through 1977 in Chautauqua Lake, New York, stated that effectivenesses in terms of reduction in percent plant cover (determined by visual observation) ranged from 20 to 95 percent, compared with that of control plots. Perkins, Boston, and Curren (1979)

conducted tests in Lake Washington (Union Bay) near Seattle to compare Aquascreen with mechanical harvesters. The Aquascreen plots in Lake Washington were successful in reducing biomass by 82 and 69 percent, relative to that of the control plots in shallow- and deep-water areas, respectively, during the period July-October 1978 (Perkins, Boston, and Curren 1979). Optimum coverage time for effective bottom screen treatment, however, was 2 months. The screen had a longer term effectiveness than the harvester with a single application; however, harvesting was superior to screening in terms of cost per unit area of treatment. These authors concluded that, although the bottom screen is effective when properly placed and maintained and relatively nontoxic to the aquatic plants, it would be best suited and most feasible for localized areas having excessive growths of aquatic plants (e.g., high-use areas) (Perkins, Boston, and Curren 1979).

Inert chemical water shades

66. A limited number of commercial concerns market inert chemical dyes that are designed to darken the water and thus prevent (or limit) the penetration of light to the plants in the water body (e.g., Aquashade, manufactured by Aquashade, Inc., of Eldred, N. Y.). These products are nontoxic to fish and wildlife. Treated water can be used for irrigation or swimming after application. The desired results will be achieved sooner if application is made before the growing season. Very little information is available on the long-term effects of chemical w ter shades, and these devices have limited utility in water bodies with high rates of water exchange.

Integrated Treatments

67. The APCRP has defined integrated treatment as the use of two or more different treatment methods to achieve the desired level of management of a problem aquatic plant population. Integrated treatments can therefore, involve any combination of chemical, mechanical, biological, or environmental management. The APCRP does not consider the use of two or more forms of the same treatment method (e.g., two biological agents,

two chemicals, etc.) as integrated treatment. The intent of integrated treatment is to achieve the desired level of plant management by combining more than one treatment method, while at the same time minimizing any deleterious (e.g., toxic) effects. As pointed out by Olkowski and Olkowski (1980), this concept is not limited to the treatment of aquatic plant populations but can be also applied to pest management activities. The most commonly integrated methods are chemical and biological; however, there is some limited documentation concerning the combination of chemical and environmental management methods. Both of these types of integrated treatments and the responses of the CE Districts are discussed.

Chemical-biological

68. The combination of 2,4-D and the alligatorweed flea beetle proved to be effective against alligatorweed populations in two Texas lakes (Gangstad et al. 1975a) and on three river systems in South Carolina (Gangstad et al. 1975b). Both studies concluded that the combination was more effective than either method used independently. Gangstad, Spencer, and Foret (1975) described several tests conducted at widely separated locations in Louisiana where 2,4-D was applied to alligatorweed plots following treatment of the plots with the alligatorweed flea beetle. The biological agent eliminated the alligatorweed, and the 2,4-D, the waterhyacinth. When only the insect had been used, waterhyacinth replaced the alligatorweed population.

69. Perkins (1977) described a 6-month experiment that was conducted in Florida using 2,4-D on populations of waterhyacinth where the mottled waterhyacinth weevil had become established. The treated plots showed a decrease in biomass followed by eventual decrease in both numbers of adult weevils per plant and numbers of feeding spots per plant (Perkins 1977). The plants treated with 2,4-D attracted the weevils, "possibly owing to release of a kariomone from waterhyacinth tissue" (Perkins 1977). Perkins (1978) discussed the use of the fungus, *Acremonium zonatum* (Saw.) Gams, and various insects in combination with a herbicide for treatment of waterhyacinth populations and stated that

the herbicide should be applied after the biological agent has begun to suppress the plants.

Chemical-environmental management

70. There is even less literature on chemical-environmental management treatment than on chemical-biological treatment. One such example involved the combination of water-level drawdown with the application of 2,4-D to treat exposed hydrilla and diquat to treat hydrilla still covered by water at Sibley Lake near Natchitoches, La. This integrated approach proved to be an efficacious treatment (Manning and Johnson 1975).

Responses of the CE Districts

71. No questions of the telephone survey specifically addressed integrated treatments; however, two of the Districts (SAC and SAS), responding to Question 13 on chemical treatment, reported using chemical-biological treatment. The SAC stated that reduced quantities of the herbicide 2,4-D (2 to 4 lb/acre instead of 8 lb/acre) were just as effective for treating alligatorweed when used in combination with the alligatorweed flea beetle. The SAS used 2,4-D in combination with the chevroned waterhyacinth weevil to achieve a synergetic effect on waterhyacinth populations.

PART V: PUBLIC AWARENESS

72. Public awareness involves the dissemination of information on an aquatic plant management program to the public. Environmental Assessments (EA's),* Environmental Impact Statements (EIS's), public meetings, and a multifaceted publicity campaign can accomplish this objective. The intent of public awareness is to inform and to solicit input from the public during the planning process and throughout all management phases. The following paragraphs provide brief descriptions of the various methods available to keep the public informed during all phases of an aquatic plant management program.

EA's and EIS's

73. The EA examines actions that normally do not require an EIS but that are not categorically excluded from environmental discrimination, while the EIS is a public document whose primary purpose is to ensure that the policies and goals defined in the National Environmental Policy Act of 1969 are infused into ongoing programs and actions of government agencies. An EA can lead to an EIS or a Findings of No Significant Impact (FNSI). The FNSI briefly presents reasons why an action will not have significant effect on the human environment and, thus, will not be the subject of an EIS. In most cases, a major treatment effort (especially when the use of herbicides is involved) requires an EIS or at least an EA.

74. Question 21 of Appendix B deals with the preparation of these documents for treatment operations. The responses of 12 Districts showed that EIS's are normally prepared for treatment operations; however, the SWT has prepared only an EA for every area it has treated thus far, and the SAW has prepared neither an EA nor an EIS thus far. In some Districts (SWF, SWG, and NPS), EIS's are being prepared or revised for the entire treatment program.

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* Formerly referred to as Environmental Impact Assessments or EIA's.

Public Meetings

75. Public meetings are held to inform the public about an aquatic plant management program and to solicit input in implementing that program. These meetings normally consist of prepared presentations followed by a question-and-answer session. A District should invite other involved Federal, State, and local agencies and concerned citizens' groups to share in the program. The individuals making the presentations at the meetings should use the most effective means available for informing the public about the various aspects of the management program (e.g., posters, slides, viewgraphs, and handouts, etc.). A CE District should make best use of its Public Affairs Office (PAO) for help in selecting the appropriate time and place for meetings and in making all necessary arrangements (including advance publicity in the local press and on area radio and television stations), and in formally notifying all concerned agencies, citizens' groups, etc.

Publicity Campaign

76. An important aspect (and often the best method of reaching the public) is the publicity campaign. A District should make full use of its PAO for help in preparing appropriate news releases for the local press and area radio and television stations and in handling arrangements and scheduling interviews with these media. The CE District management staff, with the help of the PAO, can also prepare and distribute informational brochures that describe the aquatic plant management program. Audiovisual displays in public places (e.g., parks, shopping centers, etc.) and periodic presentations to interested local organizations (e.g., civic associations, landowner organizations, and environmental groups) can also serve to inform the public of a District's aquatic plant management program.

PART VI: TRAINING

77. Training is essential for personnel involved in the operational aspects of an aquatic plant management program. This training can be conducted either in-house or at a central location in cooperation with other agencies. Content of the course material should be governed by the District's needs and priorities. Format of training can be varied; however, the most effective training consists of classroom presentations supplemented by laboratory and field exercises. Training material should include handouts that can be used as reference manuals (e.g., Florida Department of Natural Resources and U. S. Department of Agriculture 1976). Baker (1976) has documented the training program used by the Central and Southern Florida Flood Control District. A training program can include the following elements:

- a. Aquatic plant management concepts.
- b. Aquatic plant identification and population dynamics.
- c. Monitoring techniques.
- d. Treatment methods.

Aquatic Plant Management Concepts

78. For each of the basic elements of an aquatic plant management program (paragraph 6) there is a set of management concepts. Personnel involved in each of the various phases of management should acquaint themselves with all of the current prevailing methodologies in their District, not only for their own knowledge, but also to prepare for the many questions that the public often asks. For example, a CE District team that has been assigned the responsibility for monitoring or verifying public reports of problem plant populations could be confronted by boaters or fishermen with questions on treatment practices or even on some aspect of the public awareness program. These personnel should be able to either answer such questions directly or recommend someone who can provide satisfactory answers.

Aquatic Plant Identification and Population Dynamics

79. District employees involved in an aquatic plant management program should be taught how to identify both native and introduced aquatic flora that occur in their District. Laboratory exercises can include the handling of specimen plants and the application of remote-sensing techniques to plant identification (e.g., Leonard and Payne 1982). Field training, however, is the most useful means of gaining proficiency in identification. A number of manuals (e.g., Burkhalter et al. not dated; Hotchkiss 1970; and Tarver et al. 1978) have been prepared to aid in the identification of aquatic plants.

80. An important aspect of this training element is a brief introduction to population dynamics of the aquatic plant species of interest. If possible, this introduction should include such topics as modes of reproduction, life history, population densities, and growth rates. Such information is essential to those District employees who are involved in treatment operations.

Monitoring Techniques

81. Personnel involved in monitoring aquatic plant populations (see Part II) should be instructed in both ground surveying and imagery interpretation techniques as they apply to aquatic plant populations. These personnel should also be taught when each technique should be used and how the techniques can be integrated to achieve maximum benefit. Instructional matter that should be covered on both the ground and remote-sensing surveys is addressed below.

Ground surveys

82. A District conducts ground surveys (paragraphs 12-17) either in response to reports by the public or by District personnel or as part of routine periodic inspections of selected water bodies. Instruction in field surveying can be taught simultaneously with aquatic plant identification and population dynamics (paragraphs 79-80), because

field surveying involves the ability to recognize colonies of aquatic plants and to determine temporal and spatial changes in colony configuration or composition. Surveys can be performed by a combination of onshore and boat observations (as determined by the field team). The field personnel should be instructed to take sufficient photographs, notes, and measurements (e.g., physical dimensions of colonies, water depths, etc.) and use whatever published maps and remote imagery are available to map the status of the plant population.

Remote-sensing surveys

83. Remote-sensing training (paragraphs 18-22) can also be given simultaneously with the instruction on aquatic plant identification and population dynamics (paragraphs 79-80). The course of instruction can also include mapping aquatic plant distributions, making quantitative comparisons of temporal change in colony size and configuration, and using data derived from remote-sensing products in conjunction with that derived from ground surveys (paragraph 82). The program can also include general discussions of mission planning, such as the advantages and limitations of the various scales and film-filter combinations for monitoring specific aquatic plant populations.

Treatment Methods

84. If training in treatment methods (Part IV) is necessary, the material should include only the basic concepts of chemical, mechanical, biological, environmental management, and integrated treatments.

Chemical

85. If District personnel apply chemicals to treat aquatic plant populations (paragraphs 28-32), they should receive formal EPA certification as aquatic herbicide applicators. In some cases, herbicide manufacturers can provide assistance in either planning or conducting this phase of training. The course of instruction can also include the following chemical treatment concepts:

a. Effectiveness of various herbicides on plant species.

b. Application methods and equipment.

c. Herbicide handling, application safety, and application requirements. These requirements are contained in Headquarters, Department of the Army (1981).

Two examples of training manuals that can be used by the Districts who apply herbicides to treat problem aquatic plant populations are U. S. Department of Defense (1977) and USDA (not dated).

Mechanical

86. Classroom presentations and field demonstrations can provide information on the latest mechanical equipment and techniques. In general, training in mechanical treatment methods (paragraphs 34-42) needs to be only cursory but should cover the kinds of treatment available. For example, a training program need not address the details of how a mechanical harvester works because the task of operating a harvester is normally assigned to a contractor. However, District personnel should be familiarized with the feasibility of using harvesters and the advantages and limitations of such equipment. The same holds true for instruction in barrier construction, operation, and maintenance. These devices are usually constructed by one contractor and operated and maintained by another. Instruction can, however, cover the purpose of barriers, selection of barrier locations, and a recommended schedule for operation and maintenance.

Biological

87. The objective of biological treatment training (paragraphs 44-59) is to provide the field personnel with information on the biological agents that are available for treatment of problem aquatic plant populations in the District. Training should consist of classroom presentation and some field observations on state-of-the-art techniques. The level of detail at which training topics are addressed should be commensurate with the District's needs.

Environmental management

88. Most training in environmental management (paragraphs 61-66) can be accomplished with brief classroom presentations. For example, the same personnel involved in aquatic plant management will not likely control reservoir levels. A District electing to use a specific

environmental management technique (e.g., water shades or bottom screens) can often obtain necessary training directly from the manufacturer.

Integrated treatments

89. If necessary, training in integrated treatment methods (paragraphs 67-70) can be taught simultaneously and as part of a program covering other treatment methods. The most commonly integrated methods, chemical and biological, can be included as part of either chemical or biological training. Integrated treatment training should address the advantages of using more than one treatment method to gain the maximum benefits of both, while minimizing deleterious effects.

Responses of the CE Districts

90. Question 22 of Appendix B deals with training of District personnel in identification of aquatic plants. Two Districts (LMN and NPS) have received formal training in plant identification. In the 12 other Districts, the amount of training received varies from in-house instruction (often informal) to relying on identification manuals to no training at all. In those Districts where the number of problem species is limited (e.g., NAN, where only waterchestnut is a problem), the matter of training field personnel in plant identification is greatly simplified.

91. The WES also queried the 14 Districts on the training that their personnel receive in herbicide handling, safety, and application (Question 23). Only four Districts (SAJ, ORN, LMN, and SWT) have personnel specially trained in herbicide handling, safety, and application. In the remainder of the Districts (except SAW, which does not have an active aquatic plant program), herbicides are handled by a State agency with whom the District has a cost-sharing program or by a contractor whose applicator personnel are certified.

PART VII: SUMMARY

Literature Survey

92. The survey of literature published since 1970 (see References and Bibliography) addressed all five treatment elements; however, most of the published information covered the treatment element (Part IV). A few references dealt with monitoring (Part II) while practically no published material could be found on reporting (Part III), public awareness (Part V), or training (Part VI).

Telephone Survey

93. A summary by management elements of the 14 CE Districts which were surveyed on aquatic plant management methodologies (Appendix B) follows.

Monitoring (Questions 1-6)

94. Monitoring practices used by the 14 CE Districts include both ground surveys and remote-sensing surveys. All Districts attempted to identify problem plants to the species level; however, the species and their areal extents were quite varied. The level of monitoring ranged from no monitoring at all to that of monitoring any size population, no matter how small.

Reporting (Questions 7-8)

95. None of the Districts surveyed had any special forms on procedures for reporting the status of a population of problem aquatic plants. Five Districts (SWG, SAJ, LMN, SAS, and SWT) reported having forms for documenting treatment; however, only SAJ and SAS reported that their forms were computer-compatible.

Treatment (Questions 9-20)

96. Treatment practices were also varied. The herbicide most commonly used by the Districts was 2,4-D. Other important herbicides included diquat and endothall. Of the 14 Districts, 4 used mechanical methods of treatment, including SAJ (mechanical harvester), SAM (rake),

NAN (hand removal), and NPS (fragment barrier). Nine Districts reported using some form of biological treatment. Insects used on alligatorweed included alligatorweed flea beetle and the stem-boring moth; on waterhyacinth, the Argentine waterhyacinth moth, and both the chevroned and mottled waterhyacinth weevils; and on waterchestnut, the chrysomelid beetle. Only one District (LMN) reported using a pathogen, *Cercospora rodmanii*, to treat waterhyacinth populations. Both the SAJ and the SAS stated that they had released the white amur as a biological agent to treat hydrilla populations. Two Districts reported using chemical-biological integrated treatments: the SAC who used 2,4-D in combination with the alligatorweed flea beetle for treatment of alligatorweed, and the SAS, where 2,4-D was used in conjunction with the chevroned waterhyacinth weevil for treatment of waterhyacinth populations.

Public awareness (Question 21)

97. Responses of the Districts indicated that 12 Districts prepared an EIS for treatment operations. The SWT has prepared only an EA for every area it has treated thus far, and the SAW has prepared neither an EA nor an EIS thus far.

Training (Questions 22-23)

98. Two Districts (LMN and NPS) have received formal training in plant identification. In the other Districts, the amount of plant identification training received varies from in-house training to relying on plant identification manuals to no training at all. Only 4 (SAJ, ORN, LMN, and SWT) of the 14 Districts have personnel specially trained in herbicide handling, safety, and application. In the other Districts, except the SAW, herbicides are handled by a State agency or by a contractor whose applicator personnel are certified.

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Table 1

Remote-Sensing Systems and Their Application to Aquatic Plant Management*

Sensing System	Application**				Remarks
	Regional Surveys	Detailed Surveys	Emergent Plants	Submerged Plants	
Landsat	+	0	+	0	Usefulness presently limited by the minimum size of the resolution element (approximately 1 acre). Difficult to obtain a "clean signature" for a single population.
Thermal infrared	0	0	0	0	Not readily available to operations personnel and extremely costly.
Side-looking airborne radar	0	0	0	0	Not readily available to operations airborne radar personnel, has a minimum resolution of 50 ft, and is extremely costly.
Aerial photography					
Black and white	++	++	++	++	Least expensive for covering large areas, but more difficult to interpret than color.
Color	++	++	++	+++	Easy to interpret and handle and has excellent water penetration capability; ideal for submerged plants.
Color infrared	++	++	+++	++	Best contrast for emergent plants, but extremely difficult to handle (temperature control); less suitable for water penetration than black and white or color; trained interpreter required.

* Adapted from Rekas (1980).
** 0 = not suitable; + = limited suitability; ++ = suitable; +++ = optimal suitability.

Table 2

Summary of Herbicides Used in the 14 CE Districts Contacted by Telephone Survey (Appendix B, Question 13)

Herbicide	Problem Species	District(s)
Copper (Cutrine)	Brazilian elodea (*Egeria densa* Planch.)	SAC
Diquat	All problem species	SAJ
	Brazilian elodea	SAC, NAO
	Common duckweed (*Lemna minor* L.)	SAM
	Fragrant waterlily (*Nymphaea odorata* Ait.)	LMN
Endothall	Brazilian elodea	SAC, NAO
	Eurasian watermilfoil (*Myriophyllum spicatum* L.)	NPS
	Hydrilla (*Hydrilla verticillata* (L.f.) Royle)	SAM
Glyphosate (Roundup)	Giant reed (*Phragmites communis* (Trin.) Rud.)	SAC
No chemical treatment	--	NCS
Simazine (Aquazine)	Algae	LMN
2,4-D	Alligatorweed (*Alternanthera philoxeroides* (Mart.) Griseb.)	SAC, SWF, SAM
	All problem species	SAJ
	Eurasian watermilfoil	SWT, NPS, SAW
	Waterchestnut (*Trapa natans* L.)	NAN
	Waterhyacinth (*Eichhornia crassipes* (Mart.) Solms.)	SWF, SWG, SAM, LMN, SAS
	Fragrant waterlily	ORN

Table 3

Summary of Mechanical Treatment Methods Used by the 14 CE Districts Contacted by Telephone Survey (Appendix B, Question 14)

Type of Treatment	Problem Species	District(s)
Fragment barrier	Eurasian watermilfoil (*Myriophyllum spicatum* L.)	NPS
Hand removal	Waterchestnut (*Trapa natans* L.)	NAN
Mechanical harvester	Hydrilla (*Hydrilla verticillata* (L.f.) Royle)	SAJ
No mechanical treatment	--	SAC, SWF, SWG, ORN, LMN, NAO, NCS, SAS, SWT, SAW
Rake	Hydrilla Alligatorweed (*Alternanthera philoxeroides* (Mart.) Griseb.) Waterprimrose (*Ludwigia* spp.)	SAM

Table 4

Summary of Biological Treatment Methods Used by 14 CE Districts Contacted by Telephone Survey

(Appendix B, Question 15)

Type of Treatment	Problem Species	District(s)
No biological treatment	--	ORN, NAO, NCS, NPS, SWT
Insects		
Alligatorweed flea beetle (*Agasicles hydrophila* Selman and Vogt)	Alligatorweed (*Alternanthera philoxeroides* (Mart. Griseb.)	SAC, SWF, SWG, SAJ, SAM, LMN, SAS, SAW
Argentine waterhyacinth moth (*Sameodes albiguttalis* Warren)	Waterhyacinth (*Eichhornia crassipes* (Mart.) Solms.)	SAJ, LMN
Chevroned waterhyacinth weevil (*Neochetina bruchi* Hustache)	Waterhyacinth	SAJ, SAM, SAS
Chrysomelid beetle (*Galerucella nymphaeae* L.)	Waterchestnut (*Trapa natans* L.)	NAN
Mottled waterhyacinth weevil (*Neochetina eichhorniae* Warner)	Waterhyacinth	SAJ
Stem-boring moth (*Vogtia malloi* Pastrana)	Alligatorweed	SAC, SWF
Pathogen		
Cercospora rodmanii Conway	Waterhyacinth	LMN
Fish		
White amur (*Ctenopharyngodon idella* Val.)	Hydrilla (*Hydrilla verticillata* (L.f.) Royle)	SAJ, SAS

APPENDIX A: IMPORTANT PROBLEM AQUATIC PLANT SPECIES*

Common Name	Scientific Name**
	Algae
Anabaena	*Anabaena* spp.
Aphanizomenon	*Aphanizomenon* spp.
Chara	*Chara* spp.
Cladophora	*Cladophora* spp.
Hydrodictyon	*Hydrodictyon* spp.
Microcystis	*Microcystis* spp.
Nitella	*Nitella* spp.
Oedogonium	*Oedogonium* spp.
Pithophora	*Pithophora* spp.
Spirogyra	*Spirogyra* spp.
	Emergent Plants
Alligatorweed	*Alternanthera philoxeroides* (Mart.) Griseb.
American lotus	*Nelumbo lutea* (Willd.) Pers.
Arrowhead	*Sagittaria* spp.
Bulrush	*Scirpus* spp.
Cattail	*Typha* spp.
Fragrant waterlily	*Nymphaea odorata* Ait.
Frog's bit	*Limnobium spongia* (Bosc.) Steud.
Pickerelweed	*Pontederia* spp.
Slender spikerush	*Eleocharis acicularis* R. and S.
Smartweed	*Polygonum* spp.
Spatterdock	*Nuphar advena* (Ait.) Ait. f.
Waterchestnut	*Trapa natans* L.
Water pennywort	*Hydrocotyle* spp.
Waterprimrose	*Ludwigia* spp.

(Continued)

* Adapted from Decell (1977).

** Scientific names taken from Godfrey and Wooten (1979), Correll and Correll (1972), Smith (1950), and Gleason (1963).

Common Name	Scientific Name
	Emergent Plants (Continued)
Watershield	*Brasenia schreberi* Gnel.
Waterwillow	*Justicia americana* L.
	Aquatic Grasses
Cutgrass	*Leersia hexandra* (Swartz.)
Giant cutgrass	*Zizaniopsis miliacea* (Michx.) Doell and Asch.
Giant foxtail	*Setaria magna* Brisb.
Giant reed	*Phragmites communis* (Trin.) Rud.
Maidencane	*Panicum hemitomon* Schultes
Paragrass	*Panicum purpurascens* Raddi.
Sawgrass	*Cladium jamaicensis* Grantz.
Southern watergrass	*Hydrochloa carolinensis* Beauv.
Torpedograss	*Panicum repens* L.
Water paspalum	*Paspalum fluitans* (Ell.) Kunth.
	Floating Plants
Common duckweed	*Lemna minor* L.
Giant duckweed	*Spirodela* spp.
Floating waterhyacinth	*Eichhornia crassipes* (Mart.) Solms.
Salvinia	*Salvinia* spp.
Waterfern	*Azolla* spp.
Waterlettuce	*Pistia stratiotes* L.
Watermeal	*Wolffia* spp.
Wolffiella	*Wolffiella* spp.
	Submerged Plants
American elodea	*Elodea canadensis* Michx.
American pondweed	*Potamogeton nodosus* Poir.
Brazilian elodea	*Egeria densa* Planch.
Common bladderwort	*Utricularia* spp.
Coontail	*Ceratophyllum demersum* L.
Curled pondweed	*Potamogeton crispus* L.

(Continued)

Common Name	Scientific Name
	Submerged Plants (Continued)
Eelgrass-Tapegrass	*Vallisneria* spp.
Eurasian watermilfoil	*Myriophyllum spicatum* L.
Fanwort	*Cabomba caroliniana* L.
Horned pondweed	*Zannichellia palustris* L.
Hydrilla	*Hydrilla verticillata* (L.f.) Royle
Illinois pondweed	*Potamogeton illinoensis* Morong
Marine naiad	*Najas marina* L.
Parrotfeather	*Myriophyllum aquaticum* (Vell.) Verdc.
Sago pondweed	*Potamogeton pectinatus* L.
Slender naiad	*Najas minor* All.
Southern naiad	*Najas guadalupensis* (Spreng.) Mangus
Water buttercup	*Ranunculus aquatilis* L.
Widgeongrass	*Ruppia maritima* L.

APPENDIX B: TELEPHONE SURVEY OF 14 CE DISTRICTS

1. This appendix contains the 23 questions on aquatic plant management practices followed by the responses of the 14 Districts selected for the survey (paragraph 10, main text). An index for locating the questions asked on each management element is provided below:

Monitoring

Question 1

What are your District's methods for locating and monitoring a problem aquatic plant population?

Remote sensing?

Ground survey? Method of transportation?

Date of last full survey?

District	Response
Charleston (SAC)	Combination of boat and foot transportation.
Fort Worth (SWF)	Boats. Last survey was spring 1978.
Galveston (SWG)	Boats, jeeps, and planes. Flights made at altitudes of between 1000 and 1500 ft during the months March through May. Last full ground survey made by Texas Parks and Wildlife Department was in 1971.
Jacksonville (SAJ)	Air, foot, and airboat transportation. Survey by air once a month for maintenance and control. Survey no longer needed for hydrilla (*Hydrilla verticillata* (L.f.) Royle).
Mobile (SAM)	Air and boat at Lake Seminole* and boat in remainder of the District. Last full survey performed under water quality management programs in summer of 1978. No aquatic plant management programs in Alabama and Mississippi, so not surveyed.
Nashville (ORN)	No significant aquatic plant treatment programs in this District. Temperature unfavorable for growth.
New Orleans (LMN)	Plants located by boat. Surveys constant ongoing process.
New York (NAN)	Boats used by State employees to locate plants on the Hudson and Mohawk Rivers.
Norfolk (NAO)	Boats. Was not implementing any treatment measures. Possibly in the future, the District will negotiate a contract with the State (Virginia) for all problem species.

* For a comparison of boat and aerial surveys of giant cutgrass (*Zizaniopsis miliacea* (Michx.) Doell and Asch.) population at Lake Seminole, see Dardeau (1982).

Question 1 (Continued)

District	Response
St. Paul (NCS)	Very little treatment work due to lack of interest. Maximum growth in the second week of August, but by September recreational demands decrease.
Savannah (SAS)	No present problem.
Seattle (NPS)	Boat surveys and remote-sensing missions (1:10,000-scale color, flown during late summer of each year between 1000 and 1400 hr on days with 10 percent or less cloud cover). Last full survey was September 1979. Aerial photographic coverage of some Columbia River tributaries flown in 1980.
Tulsa (SWT)	Boats. Project personnel identify plants and prepare report. District dispatches environmental specialist to investigate any suspicious populations.
Wilmington (SAW)	Boats. Date of last full survey was 1974.

Question 2

How does your District determine the extent of these problem plant populations? Remote sensing, ground surveys?

District	Response
SAC	Remote-sensing and ground surveys.
SWF	Ground surveys. Heavy canopy over water bodies makes many areas inaccessible.
SWG	Ground surveys.
SAJ	Ground and aerial surveys. Was testing fathometers for operational use to determine biomass, vegetation heights, and effects of treatments.
SAM	Ground surveys.
ORN	Ground surveys. Problem only minor due to low nutrient levels and unfavorable temperature.
LMN	Ground surveys.
NAN	Ground surveys to verify reports by public.
NAO	Ground surveys to verify reports by public.
NCS	No problem.
SAS	No current (1980) problem.
NPS	Remote sensing verified by ground surveys.

Question 2 (Continued)

District	Response
SWT	Annual ground and remote-sensing surveys to pinpoint most likely problem areas, then ground surveys performed during July and August.
SAW	Remote-sensing (including Landsat imagery) surveys. Ground surveys used to determine extent of alligatorweed (*Alternanthera philoxeroides* (Mart.) Griseb.) populations.

Questions 3 and 4

Does your District try to identify problem plants to species level? What are these problem species? Primary? Secondary?

District	Response
SAC	Yes. Primary species--Brazilian elodea (*Egeria densa* Planch.) and alligatorweed. Secondary species--waterprimrose (*Ludwigia* spp.).
SWF	Yes. Primary species--floating waterhyacinth (*Eichhornia crassipes* (Mart.) Solms.)* and alligatorweed.
SWG	Yes. Primary species--waterhyacinth. Secondary species--alligatorweed.
SAJ	Yes. Primary species--waterhyacinth and hydrilla. Secondary species--spatterdock (*Nuphar advena* (Ait.) Ait. f) and alligatorweed.
SAM	Yes. Primary species--waterhyacinth and Eurasian watermilfoil (*Myriophyllum spicatum* L.). Secondary species--giant cutgrass, hydrilla, and alligatorweed.
ORN	Yes. Primary species--fragrant waterlily (*Nymphaea odorata* Ait.). Secondary species--alligatorweed, waterwillow (*Justicia americana* L.), Eurasian watermilfoil, and cattail (*Typha* spp.).
LMN	Yes. Primary species--waterhyacinth. Secondary species--waterlettuce (*Pistia stratiotes* L.) and alligatorweed.
NAN	Yes. Primary species--waterchestnut (*Trapa natans* L.).
NAO	Yes. Primary species--Brazilian elodea.
NCS	Yes. Primary species--Aphanizomenon (*Aphanizomenon* spp.).
SAS	Yes. Primary species--waterhyacinth and alligatorweed. Secondary species--Eurasian watermilfoil and hydrilla.
NPS	Yes. Primary species--Eurasian watermilfoil.

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* Hereafter referred to as waterhyacinth.

Questions 3 and 4 (Continued)

District	Response
SWT	Yes. Primary species--Eurasian watermilfoil.
SAW	Yes. Primary species--Eurasian watermilfoil. Secondary species--alligatorweed.

Quesiton 5

How extensive are the populations of problem aquatic plant species in your District?

District	Response
SAC	Santee-Cooper Project, Lake Marion, and Lake Moultrie contained 10,000 to 20,000 acres of Brazilian elodea, Slender naiad (*Najas minor* All.), and waterprimrose (1974). About 75 of 166 stream miles have problem plants. Also concerned with giant reed (*Phragmites communis* (Trin.) Rud.) and Brazilian elodea in Santee-Cooper.
SWF	Sam Rayburn Reservoir had 1,500 acres of waterhyacinth and 300 to 500 acres of alligatorweed (1976).
SWG	Public lakes had approximately 3,000 acres of waterhyacinth, 9,000 acres of hydrilla, and 18,000 acres of alligatorweed.
SAJ	56,000 acres of waterhyacinth, 51,000 acres of hydrilla, 2,000 acres of fragrant waterlilies, and 1,300 acres of other aquatic macrophytes. Information may be conservative because State of Florida claims more area.
SAM	Lake Seminole contained 8,000 acres of Eurasian watermilfoil, 4,700 acres of giant cutgrass, 2,000 acres of hydrilla, and 800 acres of waterhyacinth. The Mobile delta had 960 acres of waterhyacinth and 3,000 acres of Eurasian watermilfoil. Louisiana had 1,050 acres of waterhyacinth (1976). Belle Isle, Mississippi, had Eurasian watermilfoil, waterhyacinth, and other species. Coffeeville Lock and Dam had 10 to 12 acres of Eurasian watermilfoil and fragments of hydrilla.
ORN	No problem.
LMN	October surveys from 1970 to 1980 averaged more than 1 million acres annually.
NAN	1,340 acres of waterchestnut (1976).
NAO	Less than 17 percent of the water area in the District was covered with plants (1980).

Question 5 (Continued)

District	Response
NCS	Aerial extent was 10 percent, but this only lasted for the short growing season. Buffalo Lake had some thick native species, and Wisconsin had some Eurasian watermilfoil.
SAS	Growth depended on the severity of the winters. Fifty acres of waterhyacinth in the Satilla River, 66 acres of waterhyacinth in Lake Worth, and 30 acres of alligatorweed in Jackson Lake (1976).
NPS	1979 estimates of acreage of Eurasian watermilfoil in state of Washington: Seattle metropolitan area--900 acres; Pend Oreille River--200 acres; Banks Lake--700 acres; Lake Whatcom--20 acres; Lake Osoyoos and upper Okanogan River--75 acres.
SWT	8,200 acres in 12 major lakes and streams (1975 estimate). Robert S. Kerr Lake contained 600 acres of Eurasian watermilfoil (1976). District anticipated a major problem in Kerr Reservoir due to mild winters.
SAW	75,000 to 100,000 acres of Eurasian watermilfoil and 1,000 acres of alligatorweed.

Question 6

What is minimum size problem aquatic plant population that your District monitors?

District	Response
SAC	Monitored a population that choked a stream or covered a large portion of a lake.
SWF	Texas Parks and Wildlife Department monitored these populations.
SWG	Had the same problem areas year to year, so District monitors these. No minimum-size population monitored.
SAJ	Depended on the size of the population and the type and size water body in which it was located.
SAM	Monitored hydrilla growth. In Lake Seminole, monitored populations in boat channels.
ORN	Monitored affected areas (i.e., sizable population of 1 acre or more) to determine extent and nature of the plant problem.
LMN	Depended on the situation and the place. Monitored all new problem plant populations.
NAN	Did not monitor any populations of problem species, but attempted to treat all populations that developed.

Question 6 (Continued)

District	Response
NAO	Did not monitor any minimum size population but attempted to treat as many plants as possible.
NCS	No monitoring had been done.
SAS	Worked with SAJ, but was doing no monitoring in 1980.
NPS	Any Eurasian watermilfoil populations.
SWT	Remote-sensing mission flown four times a year. District treated only new populations detected on the imagery.
SAW	Inactive since 1974. In the past, monitored large populations, but not the smaller ones, after treatment.

Reporting

Question 7

Does your District have specific procedures for reporting population of problem aquatic plant species to treatment personnel?

By the public?

By District personnel?

District	Response
SAC	District did reconnaissance on the eastern portion of South Carolina and estimated percent coverage.
SWF	District personnel (project managers) checked the status of problem plant populations every year; if District failed to treat, public usually reported these populations.
SWG	Public reported problem plant populations, and District usually referred the information to the State (Texas Parks and Wildlife Department). State handles all treatments.
SAJ	District tailored frequency of inspection to rate of growth. Routine aeiral surveillance and airboat inspections by District and State (Florida).
SAM	State handled calls from public concerning private ponds. In 1975, District and Alabama Department of Conservation conducted some surveys for common duckweed (*Lemna minor* L.) and found Eurasian watermilfoil increasing.
ORN	District rangers patrolled water and shore and reported any problem aquatic plants to operations personnel.

Question 7 (Continued)

District	Response
LMN	Public reported problems, and District employees checked known populations every month.
NAN	Public reported problems to State authorities. District had a program with the State of New York, but now terminated. Trying to initiate a program with Vermont.
NAO	District relied on the public to report any problems.
NCS	Public reported problems to the State (Minnesota) and the State informed District.
SAS	Public reported information to the Georgia Game and Fish Commission, who reported problems to District. Field work performed by State.
NPS	In developmental stage.
SWT	Project managers and public reported to the District on the status of the problem populations. Done as an "as requested" basis.
SAW	District claimed no foreseeable problem and had no program, and, therefore, had no reporting techniques.

Question 8

Does your District have any procedures for reporting treatment measures? If yes, how does your District document these treatment measures?

Does the documentation include:

Personnel (including scheduling of treatments)

Equipment (purchases, operations, and maintenance, etc.)

Costs (salaries, travel, and aerial unit costs of treatments)

Does your District use these reports to plan future aquatic plant management operations?

District	Response
SAC	No treatment since 1974, so no procedures for documenting treatment measures.
SWF	Treatment measures documented in the form of a bill sent to the District Audit Branch, who verified that Texas Parks and Wildlife performed the work.
SWG	State sent treatment information on form to District. District used this information to plan future aquatic plant management operations.

Question 8 (Continued)

District	Response
SAJ	District Operations personnel furnished weekly report on the computer-compatible forms.* Report included data on personnel, equipment, etc., involved in treatment operations. District used report to plan future operations.
SAM	State sent daily log reports to District, and District checked effectiveness of herbicides by studying field results recorded on these logs.
ORN	District received annual report from maintenance personnel, but did not use this documentation to plan future operations.
LMN	District received log sheets from Louisiana Wildlife and Fisheries Commission. Used this information to plan future operations.
NAN	State (New York) kept a weekly log that was submitted annually to the District so that reimbursement could be made.
NAO	District had contract with Virginia Commission of Game and Inland Fisheries, which sent in periodic reports and a final report for payment. District used this information to plan future operations.
NCS	Program was new in District, and little work had been done; therefore, no methods for documenting treatment measures.
SAS	Forms included computerized documentation on chemicals used, etc. District used these data to plan future operations.
NPS	In developmental stage.
SWT	Used a control-treatment form that gave names and quantity of chemicals used, area treated, water depth, temperature, etc.
SAW	District claimed no foreseeable problems; therefore, no methods for documenting treatment measures.

Treatment

Question 9

Is your District presently taking any type of treatment measures?

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* See McGehee (1977), U. S. Army Engineer District, Jacksonville (1978), and paragraph 26, main text.

Question 9 (Continued)

District	Response
SAC	Yes. Last treatment measure taken was release of alligatorweed flea beetle (*Agasicles hygrophila* Selman and Vogt) in 1978.
SWF	Yes. Only 2 (Steinhagen Lake and Sam Rayburn Reservoir) of 17 reservoirs had problems (1980).
SWG	Yes. Field operations handled by Texas Parks and Wildlife Department.
SAJ	Yes. Budget was $5 million for FY 80.
SAM	Yes. The main problem area was Lake Seminole.
ORN	No. District had not needed to initiate any significant aquatic plant treatment program since 1976. Any projects would probably be on the Cumberland River, which had some minor problems. Projects would have to be multipurpose with power production.
LMN	Yes. District was using chemical and biological treatment methods.
NAN	No. New York State no longer cooperated with the District. Some haphazard hand removal of waterchestnut. Effective spray season short, and 2,4-D not permitted. If State cooperates, then plans will be made for a larger program.
NAO	No. District has had a program since 1976. Concluded a 3-year study on 30 June 1976 on application of endothall and diquat to Chickahominy Reservoir.
NCS	No. Short growing season. Only minor populations of problem plants. Little had been done due to a lack of public interest. Number of water bodies suitable for recreation far exceeded the demand.
SAS	No. If the State of Georgia can obtain funding, District could enter into a 70-30 agreement with the Georgia Game and Fish Commission. No program until funds available.
NPS	Yes. Washington State Department of Ecology responsible for administering prevention measures.
SWT	Yes. One main water body--Robert S. Kerr Lake.
SAW	No. Treatment in District inactive since 1974 due to a lack of local interest.

Question 10

Accessibility:

Are problem plant populations accessible by land, water, or air?

Question 10 (Continued)

What is the water depth in the problem areas?

Do narrow streams make treatment difficult in some areas?

District	Response
SAC	Treated areas accessible by boat. Water depth in problem areas less than 12 ft.
SWF	Treated areas accessible by boat. Growth over water bodies formed a thick canopy that made accessibility difficult.
SAG	Some problems with small narrow bayous limiting accessibility.
SAJ	Treated areas accessible by boat and helicopter.
SAM	Treated areas accessbile by boat.
ORN	Treated areas accessible by boat.
LMN	Some inaccessible narrow streams, but most areas accessible by land, water, and air. Mean water depth of problem area was 6 ft.
NAN	Some areas accessible only by boat. Others also accessible by jeep.
NAO	Most areas accessible by boat and jeep.
NCS	Program new in District. Little had been done due to lack of interest.
SAS	Nothing planned for treatment of aquatic plants.
NPS	Accessible by water and air. Water depth of problem areas was 3 to 35 ft.
SWT	Treated area accessible by boat.
SAW	No accessibility problem.

Question 11

What is (are) the primary use(s) of the water in the problem areas? Water supply, irrigation, recreation, navigation of large vessels? Do these problem areas have fresh or brackish waters?

District	Response
SAC	Recreation (mainly fishing and waterskiing) and navigation of large vessels.
SWF	Recreation and navigation. The plants also impeded flow, which produced ideal habitat for mosquitoes.

Question 11 (Continued)

District	Response
SWG	Recreation and navigation. Alligatorweed growing in the brackish waters, and waterhyacinth growing in the fresh waters.
SAJ	Irrigation, navigation, and recreation (including fishing).
SAM	Recreation.
ORN	Navigation and power production.
LMN	Recreation and navigation.
NAN	Recreation and navigation. Waterchestnut populations caused problem at water intakes, hurt hunting by crowding out duck food, and cut off bays for fishing and boating.
NAO	Recreation and water supply.
NCS	No problem.
SAS	Recreation and navigation.
NPS	Navigation, recreation, irrigation, and water supply.
SWT	Irrigation, recreation, and navigation; however, a number of areas still available for fishing.
SAW	Recreation.

Question 12

Which problem areas would likely receive priority consideration for treatment measures?

District	Response
SAC	Any problem area.
SWF	Marinas.
SWG	High-use areas.
SAJ	Any problem area.
SAM	Backwater streams.
ORN	No problem.
LMN	Any problem area.
NAN	District no longer had an active aquatic plant treatment program. In the past, the most likely candidates for treatment were marinas and channels into closed-off bays.
NAO	No aquatic plant treatment program since 1976. In the past, all problem areas were treated.

Question 12 (Continued)

District	Response
NCS	Program new in District. Little had been done due to lack of public interest.
SAS	Any problem area.
NPS	Tributaries of the Columbia River.
SWT	Any new problem areas detected by remote-sensing missions (flown four times annually).
SAW	Any problem area.

Question 13

Chemical treatment.

What chemicals are used?

What formulations?

Quantities?

When applied?

How applied?

Who applies the chemicals?

What equipment is used?

District	Response
SAC	Diquat on Brazilian elodea. 2,4-D on alligatorweed. 2,4-D used at a rate of 8 lb acid equivalent/acre for treatment, but in integrated treatment with the alligatorweed flea beetle. District used 2 to 4 lb/acre. Good results with 2,4-D. Diquat effective for a short time, but plants spread to previously unaffected areas. Also field trials conducted with cutrine and endothall on Brazilian elodea and Roundup on giant reed.
SWF	2,4-D (DMA) in quantities of 2 to 4 lb acid equivalent/acre applied continuously to alligatorweed and waterhyacinth prior to 1976 by Texas Parks and Wildlife Department--a 70-30 Federal-State agreement. Treatment 90 percent effective.
SWG	2,4-D (4 lb/acre) for waterhyacinth with appropriate spreader sticker additives to ensure adhesion to plants. Good results.
SAJ	2,4-D (DMA) and diquat applied by helicopter and airboat with spray nozzle injection in varying concentrations. Two thirds of treatment work contracted, and one third performed by District personnel. Good results.

Question 13 (Continued)

District	Response
SAM	Liquid and 200 lb/acre granular endothall (once in 1975) on hydrilla; diquat on common duckweed in Alabama; 2,4-D (DMA) on waterhyacinth and alligatorweed. 2,4-D (DMA) applied during late summer in quantities of 4 lb/acre using boomless sprayers by airboats or planes. Good results from 2,4-D (DMA).
ORN	Rangers occasionally treated fragrant waterlily populations of 1 acre or more using 2,4-D (DMA).
LMN	Used aquazine on algae blooms, diquat on fragrant waterlilies, and 2,4-D on waterhyacinth. Louisiana Wildlife and Fisheries Commission did 75 percent of the spraying, and the District did remainder. Chemicals applied by spray boat, airboat, mud boat, and sometimes helicopter.
NAN	2,4-D in quantities of 8 lb acid equivalent/acre on waterchestnut. Large populations treated using boat-spraying units. Smaller populations hand sprayed. For spraying to be effective, no seed formation could be permitted. Hand spraying preferred because less error involved.
NAO	Virginia Commission on Game and Inland Fisheries used sprayer on airboat to apply 7.6 gal/acre of endothall and diquat in liquid form from 1 July 1973 to 30 June 1976. Good results. No complaints from public since last application in 1976.
NCS	District had never used and had no future plans to use any chemical treatment.
SAS	2,4-D for waterhyacinth treatment, applied by air or sprayed from boats. Had 70-30 Federal-State agreement with Georgia Game and Fish Commission. Good results. Chemical and biological treatments (i.e., 2,4-D and chevroned waterhyacinth weevil (*Neochetina bruchi* Hustache)) worked together to achieve a synergistic effect on waterhyacinths.
NPS	Washington State Department of Ecology responsible for herbicide application through a 70-30 cost-sharing program with NPS. Endothall and 2,4-D (BEE) and (DMA) used for treatment of Eurasian watermilfoil.
SWT	2,4-D (BEE) in granular form (20 percent or higher, as necessary; active ingredient, 100 lb/acre), to treat Eurasian watermilfoil. Treatments (including water quality) monitored for 20 days after application.
SAW	Inactive since 1974, but prior to that date used 2,4-D granules on Eurasian watermilfoil. Regrowth since last application.

Question 14

Mechanical treatment.

What type of equipment?

Any problems with operation of equipment?

Kind of disposal method?

Must you transport to disposal area?

Clearing rates?

What species controlled this way?

Success with approach?

How does your District define success?

District	Response
SAC	No mechanical treatment.
SWF	No mechancial treatment.
SWG	No mechanical treatment.
SAJ	Harvested hydrilla with an Aqua-Trio harvester, shore conveyor, and transporter. Used a dump truck to carry plants to the disposal area. Competed with chemical control. Cost (1980) was $150-200/acre.
SAM	Mechanical treatment (rake driven by manual labor) used on hydrilla, alligatorweed, and waterprimrose. This method used occasionally for clearing around boat ramps.
ORN	No mechanical treatment.
LMN	No mechanical treatment.
NAN	Used mechanical treatment on waterchestnut. Some small populations hand removed from a canoe. Some problems with mechanical control due to the shallow depths and inability to bring equipment to some of back-bay and tidal areas.
NAO	No mechanical treatment.
NCS	Some mechanical treatment research performed at the University of Wisconsin.
SAS	No mechanical treatment.
NPS	Used a fragment barrier system designed to prevent or hinder the downstream dispersal of Eurasian watermilfoil fragments on the Okanogan River.* Disposal was shore compost pile. Barrier needed to be cleaned and

* See Dardeau and Lazor (1982) and paragraph 38, main text.

Question 14 (Continued)

District	Response
NPS (Continued)	maintained on a twice-weekly schedule to remain effective. Mechanical harvester research performed at University of Washington.
SWT	No mechanical treatment.
SAW	No mechanical treatment.

Question 15

Biological treatment.

What agents used?

Insects: what species on what plant(s)?

Pathogens: what species on what plant(s)?

Fishes: what species on what plant(s)?

Other types of biological treatment?

Last date released to system?

Results?

District	Response
SAC	Alligatorweed flea beetle and stem-boring moth (*Vogtia malloi* Pastrana) used to treat alligatorweed. Cold weather killed much of the insect population, but more introduced from SAJ. Both insects performed adequately, but beetle gave best results.
SWF	Alligatorweed flea beetle and stem-boring moth used to treat alligatorweed. Insect populations spotty due to temperature fluctuations and other erratic weather conditions. Insects last released into system in the 1960's. Some experimental insects tested (1980).
SWG	Alligatorweed flea beetle used to treat alligatorweed. Only limited success due to several factors, including erratic weather conditions.
SAJ	Several insects, including mottled waterhyacinth weevil (*Neochetina eichhorniae* Warner), chevroned waterhyacinth weevil, and Argentine waterhyacinth moth (*Sameodes albiguttalis* Warren) used to treat waterhyacinth. Alligatorweed flea beetle used to treat alligatorweed with good results. Research was being conducted on pathogens and fishes. White amur (*Ctenopharyngodon idella* Val.) used in Lake Conway on hydrilla.
SAM	Chevroned waterhyacinth weevil used on waterhyacinth, and

Question 15 (Continued)

District	Response
SAM (Continued)	alligatorweed flea beetle used on alligatorweed. Weevil populations slowly increasing. Beetle populations, affected by cold weather, but had been reintroduced and considered effective.
ORN	No biological treatment.
LMN	Used the fungus, *Cercospora rodmanii* Conway, chevroned and mottled waterhyacinth weevils, and Argentine waterhyacinth moth on waterhyacinth. Alligatorweed flea beetle used on alliatorweed.
NAN	Chrysomelid beetle (*Galerucella nymphaeae* L.) used on waterchestnut. Insect did not inflict serious damage to plants.
NAO	No biological treatment.
NCS	No biological treatment.
SAS	Alligatorweed flea beetle used to treat alligatorweed, and chevroned waterhyacinth weevil used to treat waterhyacinth. White amur used on hydrilla. Alligatorweed flea beetle successful. Effectiveness of chevroned waterhyacinth weevil and white amur not yet determined.
NPS	No biological treatment.
SWT	No biological treatment.
SAW	Released alligatorweed flea beetle in 1967 for treatment of alligatorweed. Considered unsuccessful because beetles had little effect on the plants during late summer when plant growth is maximum.

Quesiton 16

Are funding operations adequate?

District	Response
SAC	Yes.
SWF	Yes. 70-30 Federal-State agreement.
SWG	Yes. The Texas Parks and Wildlife Department did field work.
SAJ	Yes. Sufficient funding available because of the overwhelming extent of plant growth in Florida.
SAM	Yes.
ORN	Yes. No significant aquatic plant treatment programs since 1976.

Question 16 (Continued)

District	Response
LMN	Yes. Louisiana Wildlife and Fisheries Commission did three fourths of the work for the District.
NAN	Yes. Presently no aquatic plant treatment because New York State no longer had a cooperative agreement with District.
NAO	No. No aquatic plant treatment since 1976 when District concluded a 3-year study on the application of endothall and diquat to Chickahominy Reservoir.
NCS	Yes. Aquatic plant treatment program suffered from a lack of interest. Number of water bodies suitable for recreation exceeded the demand.
SAS	No. District relying on State funds to start a new program. Would like to enter into a 70-30 agreement with the field work being done by the Georgia Game and Fish Commission.
NPS	Yes. Funding adequate on 70-30 cost-sharing program.
SWT	Yes.
SAW	No. Inactive since 1974 due to a lack of local interest.

Question 17

Which problem species are not presently being treated?

District	Response
SAC	All problem species being treated.
SWF	Waterhyacinth.
SWG	All problem species being treated.
SAJ	Only plants that District not authorized to treat.
SAM	Giant cutgrass.
ORN	All problem species being treated.
LMN	Most of the submerged problem species (e.g., hydrilla).
NAN	All problem species being treated.
NAO	No problem species being treated.
NCS	No problem species being treated.
SAS	No problem species being treated.
NPS	Eurasian watermilfoil was the only problem species in the State of Washington, and it was being treated.

Question 17 (Continued)

District	Response
SWT	All problem species being treated.
SAW	No problem species being treated.

Question 18

What is minimum size population that your District considers dangerous or worthy of treatment?

District	Response
SAC	Considered the site before determining whether or not a population was dangerous (e.g., a population that was dangerous to a narrow stream could pose no threat to a large lake).
SWF	Considered every size population dangerous--no minimum size.
SWG	In a large water body, any population having an area of 10 acres or more was considered dangerous.
SAJ	Size of the water body, size of population, and species involved were factors in determining how dangerous a population was. More treatment effort was needed for certain water bodies and certain species. If a population was small, District could try for complete eradication.
SAM	Species determine danger of situation. Hydrilla treated immediately. Alligatorweed or waterhyacinth treated if choking a channel.
ORN	District considered any population larger than 1 acre dangerous.
LMN	No specific size. Any new problem populations considered dangerous.
NAN	All problem populations treated. Size of the population determined if it would be treated by hand removal or boat spraying.
NAO	District tried to treat as many problem populations as possible because of the adverse effects on reservoirs.
NCS	District new to aquatic plant management; therefore, no such values determined.
SAS	Site-dependent. Problem population dangerous when it either blocked a stream channel or exceeded 1 acre in size in a water body.
NPS	In NPS prevention program, any size population of Eurasian watermilfoil considered worthy of treatment.

Question 18 (Continued)

District	Response
SWT	Particular site determined necessity of treatment. Depended on water body and locality within the water body.
SAW	Every size problem population considered dangerous--no minimum size.

Question 19 and 20

Does your District differentiate between prevention, maintenance, and control measures?

What prevention, maintenance, or control measures do your District use?

District	Response
SAC	Yes. By using varying amounts of chemicals. For control, 8 lb/acre and for prevention, from 2 to 4 lb/acre.
SWF	No.
SWG	Yes.
SAJ	No.
SAM	Yes. For hydrilla, prevention; if one plant seen, it was treated. For waterhyacinth, maintenance and control, but not prevention, practiced.
ORN	No significant aquatic plant treatment programs initiated since 1976; no plant problem.
LMN	Yes. Differentiated between maintenance and control, but no prevention measures practiced.
NAN	No.
NAO	No.
NCS	No.
SAS	No.
NPS	Yes.
SWT	Yes. For control, District used granular formulation.
SAW	Yes. Took 1 to 2 years to achieve desired level of management, then prevention measures taken.

Public Awareness

Question 21

Does your District prepare an EA or an EIS for a treatment operation?

District	Response
SAC	EIS.
SWF	Recommended EIS for both of the treated reservoirs (Steinhagen Lake and Sam Rayburn Reservoir).
SWG	EIS for the existing treatment program. Needed a revised EIS for hydrilla treatment.
SAJ	EIS.
SAM	EIS.
ORN	No significant aquatic plant treatment programs since 1976, so neither EA nor EIS prepared.
LMN	EIS.
NAN	EIS.
NAO	Not treating any aquatic plant populations, but prepared an EIS in 1972.
NCS	Neither EA nor EIS.
SAS	EIS.
NPS	Prepared an EIS for overall treatment program.
SWT	EA (but not EIS) for every area treated.
SAW	Essentially inactive since 1974. Neither EA nor EIS had been prepared thus far.

Training

Question 22

Do District field survey personnel receive training in the identification of problem aquatic plant species?

District	Response
SAC	In the past, all field work contracted, so District personnel not trained.
SWF	District had booklets but no formal training.

Question 22 (Continued)

District	Response
SWG	Professionals, such as biologists, trained, but not all field personnel.
SAJ	Key field personnel could identify the plants.
SAM	District had identification manuals but no formal training.
ORN	No.
LMN	Yes. Course taught by WES* in 1978. Since 1978, District office personnel have trained field personnel.
NAN	District had only one problem species, waterchestnut, and field personnel could identify it.
NAO	Yes. Field personnel could identify plants to the species level.
NCS	Yes. Field personnel could identify plants to the species level.
SAS	Field personnel trained in some botany.
NPS	Yes. WES personnel presented two workshops to train District personnel.
SWT	Field personnel could not identify plants; however, experts from the office sent to the field to observe and classify the plants.
SAW	No foreseeable problems, so field personnel had no plants to identify.

Question 23

Do District applicator personnel receive training in herbicide handling, safety, and application?

District	Response
SAC	In the past, field work was contracted, so District personnel were not trained in herbicide handling.
SWF	Ninety-five percent of treatment work contracted, so no formal training. Personnel at most projects had passed a general Corps of Engineers (CE) test and a correspondence course.
SWG	State personnel who handle all herbicides were trained. District did not handle herbicides.

* U. S. Army Engineer Waterways Experiment Station.

Question 23 (Continued)

District	Response
SAJ	Key field people certified by State. State contractors also certified under the U. S. Environmental Protection Agency program.
SAM	State handled some of the contract work. For navigational reasons, the District operations personnel sprayed some areas, and these personnel followed the Federal Pesticide Handling Manual and the herbicide label.
ORN	Yes.
LMN	Yes. Supervisors in the field taught field employees and conducted weekly safety meetings.
NAN	State personnel did the field work, and they were certified. Both New York and Vermont declined the use of chemicals.
NAO	Contracted to Virginia Commission on Game and Inland Fisheries. State personnel certified.
NCS	Chemical firms handled herbicide application, so District personnel not trained.
SAS	Had a 70-30 agreement with Georgia Department of Natural Resources (GDNR) for spraying work. The GDNR's 30 percent provided the trained field crew.
NPS	District had 70-30 cost-sharing program with Washington State Department of Ecology. State contracted application to certified applicators who must follow State and Federal regulations.
SWT	Yes. Trained and certified by the required course.
SAW	District did not have active aquatic plant program, so no need for training in herbicide handling.

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Dardeau, Elba A.
Inventory and assessment of aquatic plant management methodologies / by Elba A. Dardeau, Jr., Elizabeth A. Hogg (Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; Springfield, Va. : available from NTIS, 1983.
86 p. in various pagings : ill. ; 27 cm. -- (Technical report ; A-83-2)
Cover title.
"January 1983."
Final report.
"Prepared for Office, Chief of Engineers, U.S. Army."
At head of title: Aquatic Plant Control Research Program.
Bibliography: p.55-56.

Dardeau, Elba A.
Inventory and assessment of aquatic plant ; ... 1983.
(Card 2)

1. Aquatic plants. 2. Aquatic weeds. 3. Management. 4. Operations research. I. Hogg, Elizabeth A. II. United States. Army. Corps of Engineers. Office of the Chief of Engineers. III. Aquatic Plant Control Research Program. IV. U.S. Army Engineer Waterways Experiment Station. Environmental Laboratory. V. Title. VI. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; A-83-2

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